Hazardous Waste Section

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EPA ID:	NCD024599011
Facility Name:	Former Ashland Greensboro
Document Group:	Corrective Action (CA)
Document Type:	Corrective Measures Study (CMS)
Description:	Received 2014 Corrective Measures Study - Stabilization
Date of Doc:	10/3/2014
Author of Doc:	Ashland

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Corrective Measures Study

Former Ashland Inc. Facility,
2802 Patterson St.
Greensboro, North Carolina

EPA ID No: NCD 024 599 011

October 3, 2014

ARCADIS

Corrective Measures Study

Former Ashland Inc. Facility
2802 Patterson St.
Greensboro, NC

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Our Ref.:
OH007000.NC07.14100

Date:
October 3, 2014

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Executive Summary

The objective of this Corrective Measures Study (CMS) report is to develop and evaluate corrective measure alternatives (CMAs) in order to recommend a final selected corrective measure(s) for the constituents of potential concern (COPCs) in environmental media at the former Ashland Inc. facility located at 2802 Patterson St. in Greensboro, North Carolina (the “Facility”), and at an adjacent property located at 2800 Patterson St. (combined areas containing COPCs referred to as the “Site”). Several investigation and evaluation steps, as detailed in this report, were required to properly assess the most appropriate corrective measures for the Site. Brief summaries of previous investigations and interim corrective measures performed at the Site are presented in Section 2 of this report.

Section 3 presents the results of the Site investigations performed from 2008 to 2013 to refine the Conceptual Site Model, to evaluate human health and ecological risks, and to assess the natural attenuation mechanisms for COPCs within groundwater. Results were presented in a Resource Conservation and Recovery Act Facility Investigation (RFI) report (ARCADIS 2013c) and indicated that there are no unacceptable risks to human health or the environment from Site COPCs, that natural attenuation of COPCs is occurring within groundwater, and that the groundwater plume has stabilized and/or is slightly attenuating over time.

Media-specific Cleanup Standards (MCSs) were generated in Section 4 of this report to define areas where corrective measures are required and to establish the final treatment goals for COPCs within soil and groundwater. The corrective measures are designed to reduce the potential risks identified in the RFI (ARCADIS 2013c) and will be implemented at the Site until the MCSs are achieved.

Section 5 presents the remedial technology screening process and the CMAs that were assembled and evaluated against nine performance criteria. As presented in Section 6, final corrective measures for both soil and groundwater were selected based on the best performance in regard to the evaluation criteria. The corrective measure selected to remediate soil at the Site is SCMA-5: *In-Situ* Soil Solidification with Institutional Controls (ICs). The corrective measure selected to remediate groundwater at the Site is GCMA-3: Monitored Natural Attenuation (MNA) and ICs.

1. Introduction

On behalf of Ashland, Inc. (Ashland), ARCADIS G&M of North Carolina, Inc. (ARCADIS) has prepared this Corrective Measures Study (CMS) to evaluate and select the most appropriate remedial strategy for the former chemical distribution facility (the “Facility”) located at 2802 Patterson St. in Greensboro, North Carolina (EPA ID No. NCD 024 599 011), and the surrounding areas where Ashland’s constituents of potential concern (COPCs) are present in soil and/or groundwater (the “Site”). **Figure 1-1** depicts the location of the Facility. The layout of Ashland’s former Facility is included as **Figure 1-2**.

1.1 Objectives

The purpose of the CMS portion of the Resource Conservation and Recovery Act (RCRA) corrective action process is to develop and evaluate corrective measure alternative (CMAs) and to recommend the final selected corrective measure for impacted media at the Site. Media-specific Cleanup Standards (MCSs) were generated to identify areas where corrective measures are required. The CMS presents the media and areas requiring remedial evaluation, as well as the technology evaluation and corrective measure selection to achieve Site corrective action objectives.

1.2 Report Organization

This report includes seven sections, including this introduction. Section 2 includes discussions of the Site’s background and history, general findings from the RCRA Facility Investigation (RFI) (ARCADIS 2013c) and a summary of interim corrective measures completed to date. Section 3 summarizes the updated conceptual site model (CSM) and results from remedial design data collection activities performed in June 2014 to refine the remedial strategies being considered. The approach for developing CMAs and identification of corrective action objectives, MCSs, and the media and areas requiring remedial evaluation are provided in Section 4. Section 5 presents the screening of remedial technologies, describes the assembled CMAs, and summarizes the detailed evaluations. The justification and recommendation for the final corrective actions for the Site are provided in Section 6. References are provided in Section 7.

2. Site Background and History

2.1 Site Description

Ashland's former Facility at 2802 Patterson Street, Greensboro North Carolina (**Figure 1-1**) was constructed in 1954 and operated continuously until July 2001. Between 1954 and 1968, the Facility was owned by F.H. Ross Company, a distributor of commercial laundry supplies and industrial solvents. Ashland purchased the facility in 1968, and then operated it as a distribution center for bulk industrial chemicals and solvents until 2001. The Facility was permanently closed in June 2002 and then sold to the Koury Corporation (the current owner) in June 2003 for hotel maintenance and storage activities. The approximately 1.7 acre Facility consisted of a 21,000 square-foot warehouse and office building, a railroad spur and rail car off-loading area, three above ground storage tank (AST) areas, and two covered outdoor sheds. The AST areas were completely contained within concrete secondary containment areas. The railroad spur and off-loading area and one of the outdoor storage sheds are no longer present, with the only remnants being several concrete saddles and a retaining wall for the former tank farm. The ground surface over most of the outdoor areas is covered with asphalt or concrete.

During Ashland's former operations, up to 20 ASTs and 7 underground storage tanks (USTs) were used for the storage of bulk products in both liquid and dry form. The products were shipped to the Facility via truck and rail car where they were blended, repackaged, and distributed to local industries using tanker trucks, drums, and other packaging suitable for dry products. Loading, unloading, and storage of bulk chemicals were primarily focused in the northern portion of the Facility near the former ASTs, USTs, and railroad spur.

Deed restrictions and environmental covenants were included in the sale of the property to the Koury Corporation in 2003. Land use is restricted to commercial/industrial purposes, and prohibits the construction of subsurface structures (other than building walls and footers) and the use of groundwater as a source of drinking water. A chain-linked fence surrounds and secures the property and access control is provided by a locked manually-operated gate. A second locked, manually-operated gate is present in the northeastern portion of the property which allows access to the northern portion of the Johnston Property.

2.2 Relevant RCRA Permits and Processes

2.2.1 RCRA Permit Status

On April 11, 1983 Ashland submitted a RCRA Part B permit application to the North Carolina Department of Environment and Natural Resources (NCDENR) Hazardous Waste Section (HWS) to operate a hazardous waste storage pad at the Facility. The first RCRA Hazardous Waste Management Permit was issued on July 5, 1984. In accordance with the permit, Ashland was authorized to store hazardous waste(s) in a container storage unit consisting of a concrete pad with a maximum storage capacity of 100 55-gallon containers. Various permit modifications were submitted to add and/or pursue closure for the Facility's hazardous waste management unit (HWMU). In January 2003, Ashland submitted a request to modify the Facility's post-closure plan. The modified post-closure plan was approved in March 2003, and requires maintenance of a concrete cap overlying the location of a former UST historically used for spill containment, regular monitoring of groundwater, restricting access by maintenance of the security fence around the 1.7 acre parcel, and inspections of the concrete cap and monitoring wells under 40 Code of Federal Regulations (CFR) 265.

Prior to 2003, the former Ashland facility was considered a large quantity generator (LQG) of hazardous waste under the RCRA guidelines. In February 2003, NCDENR-HWS approved a change in status from LQG to conditionally-exempt small quantity generator. In August 2003, a re-notification was performed and the Facility was issued small quantity generator status.

An Administrative Order was required in lieu of a traditional Post-Closure Permit to provide a more enforceable mechanism to govern future corrective actions for the Site, because Ashland no longer owns the Facility. The public comment period for this Administrative Order began on April 28, 2013 and ended on June 12, 2013. The final Administrative Order was issued on September 11, 2013.

2.2.2 RCRA Facility Assessment (RFA)

URS Corporation (URS 2006) completed a RCRA Facility Assessment (RFA) for the Facility in November 2006. The RFA is typically the initial step in the RCRA corrective action process, and provides the basis for determining:

- Whether releases to environmental media might have occurred,
- What types of further investigations or interim measure (IM), if any, might be required,

- Identifies Solid Waste Management Units (SWMUs) and/or Areas of Concern (AOCs) from which actual or potential releases of regulated wastes or regulated constituents might have occurred, and
- Identifies the potential need for further corrective actions.

The RFA identified two SWMUs and nine AOCs, as provided in **Figure 2-1**. Descriptions of each SWMU and AOC are provided in the RFA (URS 2006) as well as the RFI (ARCADIS 2013c).

2.2.3 Current Regulatory Requirements

Regulatory requirements within the Administrative Order (NCDENR 2013) stipulate the following needs:

1) to identify releases of hazardous waste, hazardous constituents, and petroleum constituents from the Facility;
2) to remove, if identified, imminent threats to human health and the environment through source removal or treatment;
3) to characterize the geologic and hydrogeologic conditions and determine the extent of contamination at the Facility and beyond the Facility boundaries as necessary;
4) to perform Corrective Actions, as defined in Paragraph IV.A.8. at the Facility and beyond the Facility boundaries as necessary;
5) to establish remediation goals for the Facility and to conduct remediation to meet those goals;
6) to implement and maintain a comprehensive monitoring program until remediation is complete;
7) to provide opportunities for public participation; and,
8) to provide financial assurance for completion of post-closure care for the HWMU (or regulated unit) and for completion of Corrective Action, as defined in Section IV.A.8, at the Facility and beyond the Facility boundaries as necessary.

Ashland is complying with the requirements of the Administrative Order by completing the RFI activities in 2013, completing this CMS Report, and through planning future corrective measures at the Site.

2.3 Surrounding Land Use

2.3.1 Property Zoning

Land use immediately surrounding the Facility, and further to the east and west along Patterson Street is primarily classified as industrial and commercial (see **Figure 2-2**). Zoning descriptions of the surrounding properties including their current and prior uses were provided in the RFI (ARCADIS 2013c). Based on information from the City of Greensboro's Website (http://images.greensboro-nc.gov/maingisviewer/default.htm), land use in the area includes Light or Heavy Industrial (HI), Light Industrial (CD-LI), and Office, Retail, and Commercial Uses (C-M) (**Appendix A**). Beyond approximately ¼ mile south and southeast of the Facility, the land use is primarily residential. An Unnamed Stream emerges from a storm water drain in the residential area on Immanuel Road. Historic aerial photographs of this area indicate the Unnamed Stream originally extended north of Immanuel Road (**Figure 1-1**), before it was filled and converted to a municipal storm sewer during the mid 1950s. The Unnamed Stream flows south for approximately 1 mile before draining into South Buffalo Creek.

2.4 Summary of Interim and/or Corrective Measures Performed

Several IMs have been completed at the Site to recover, remediate, or mitigate COPC concentrations in soil, groundwater, soil gas, and indoor air. IMs were detailed in the RFI (ARCADIS 2013c). The IMs included the construction of a low-permeability RCRA cover over a selected area of soil containing COPCs, the installation of a light non-aqueous phase liquid (LNAPL) recovery system in two monitor wells (MW-5 and MW-6) located to the north of the former Ashland building, installation of an Accelerated Remedial Technologies (ART) system to remove COPC mass from soil and groundwater, and installation of a Sub-Slab Depressurization (SSD) System to mitigate potential vapor migration in the building located at 2800 Patterson Street. These IMs are summarized in the following sections.

2.4.1 UST Closures and RCRA Cover

A total of seven USTs were used at the Facility for the storage of bulk products in both liquid and dry form. These tanks were removed in 1992 and impacted soil was removed during the excavation; the exact quantity was not reported. The excavations were backfilled with clean soil.

The 2,000 gallon Hazardous Waste UST was used as a product recovery tank. The tank and the underground drain lines were removed in 1993. Approximately 15 tons of backfill material were removed from the tank cavity until native soil was encountered. The excavation cavity was then lined with a double layer of 10-mil polyethylene plastic sheeting and filled with gravel. The backfill material was transported off the Site and disposed of at CWM Resource Management, Inc., Marrow, Georgia. The manifest for these materials was provided in the Closure Certification Report (Environmental Strategies Corporation [ESC] 1995).

After the Hazardous Waste UST was removed an impermeable concrete cap was emplaced over the cavity to minimize the leaching of COPCs into groundwater. The concrete cap is composed of 10 inches of Type I concrete (rated for 4,000 pounds per square inch) with two layers of reinforcing steel, and extends from the northeast corner of the building, approximately 40 feet (ft) west, 35 ft east, and 35 ft north (ESC 1995).

2.4.2 LNAPL Recovery System

Limited quantities of LNAPL have been observed intermittently in monitor wells MW-5 and MW-6 from 1993 to 2010. In August 2006, an LNAPL recovery system was installed in monitor wells MW-5 and MW-6, which consisted of a pneumatic bladder pump and a specific gravity skimmer to remove floating product (URS 2006). LNAPL thicknesses have been monitored at these locations since 2006 to assess the effectiveness of the LNAPL recovery operations. The system was deactivated in 2008 due to the general absence of LNAPL in both monitor wells, and no LNAPL has been observed in either well during periodic gauging events since 2010.

2.4.3 Accelerated Remediation Technology System

In June 2005, URS installed an ART system at the Facility, which is a remedial technology that combines *in situ* air stripping, air sparging, soil vapor extraction, and enhanced aerobic bioremediation, with a below ground dynamic groundwater recirculation system. This system included six dual-phase groundwater and soil gas recovery wells installed within and immediately downgradient of the identified source areas at the Facility. The location of recovery wells RW-1 through RW-6 associated with the ART system are presented on **Figure 1-2**. The ART system began operations in February 2007. Extracted soil gas generated from the ART process was treated through two activated carbon vessels prior to being released to the atmosphere. Based on mass removal rate estimates developed by ARCADIS in 2009 from periodic volatile organic compounds (VOC) measurements of the system exhaust, it was estimated that approximately 50 to 250 pounds of VOCs were extracted from the subsurface each year. Approximately half of the mass was attributable to tetrachloroethene (PCE). The ART system does not generate any purge water due to its design.

The continued benefit of the ART system was not well understood, and the aeration of groundwater by this system may have been inhibiting naturally occurring in-situ reductive dechlorination. For these reasons the ART system was deactivated in May 2013 to evaluate the effect of the system shutdown on groundwater COPC concentrations. Further explanation of this evaluation was provided in a letter report titled *Proposed ART Remedial System Evaluation* (ARCADIS 2013b) that was submitted to NCDENR on February 27, 2013.

Based on historical data collected from the wells located downgradient of the ART treatment wells (presented in Figures 4 through 6 in the June 2014 Semi-Annual Groundwater and Quarterly Surface Water Sampling Report [ARCADIS 2014]), no beneficial effect of the ART system was observed during operation of the system compared to periods before and after operation. Further, concentrations of PCE biological degradation compounds produced via the anaerobic degradation pathway have increased significantly in several wells since deactivation of the treatment system. These increases in degradation compounds may be due to the presence of increasingly anaerobic conditions, which were previously hampered by introduction of large volumes of air to the groundwater during the ART system stripping process. Based on these results, the ART system should not be a component of the final groundwater remedy and the system should be removed from the Site during implementation of the corrective measures.

2.4.4 Sub-Slab Depressurization System

ARCADIS conducted an indoor air sampling event in the building on the adjacent Johnston Property in September 2010 to evaluate the potential for vapor intrusion of COPCs. The first sampling event identified PCE, trichloroethene (TCE), and chloroform above the Inactive Hazardous Sites Branch (IHSB) Industrial/Commercial Indoor Air Screening Levels. Visible potential routes of entry through the concrete slab were sealed in January of 2011 to reduce the potential for vapor intrusion. A follow-on indoor air sampling event in February 2011 identified COPCs were still present within indoor air above the IHSB Screening levels.

After pilot testing activities in 2011, ARCADIS designed and installed an SSD system in December 2012 to mitigate the elevated levels of COPCs in the Johnston Properties building. A subsequent indoor air sampling event was performed on December 19, 2012, 9 days after SSD system start-up. Results of the indoor air sampling indicated that the SSD system was mitigating COPC migration into indoor air to acceptable levels. Details of the SSD system and the sampling and pilot testing were provided to NCDENR in the letter report titled Sub-*Slab Depressurization System Completion Report for the Johnston Properties Building located at 2800 Patterson St.*, on February 21, 2013 (ARCADIS 2013a).

3. RFI Investigations and Updated Conceptual Site Model

3.1 Historic Investigations from 1988 to 2008

Multiple phases of environmental investigations have been conducted at the Site since 1988 by previous consultants. A timeline summarizing the multiple phases of investigation is presented in **Appendix B**, and includes the following:

- Hydrogeologic Investigation Report (T.M. Gates 1988)
- Subsurface Investigation Report (Sirrine 1992)
- 1993 Soil and Groundwater Investigation (Rust 1993)
- Summary of Additional Soil Investigation of the Former Underground Hazardous Waste Storage Tank (ESC 1994)
- Groundwater Assessment Report (Woodward-Clyde 1995)
- Phase II Groundwater Assessment (ESC 1999)
- Site Conceptual Model & Phase II Assessment Workplan (ESC 2000)

The initial phases of investigation identified two material handling areas, which were determined to be source areas for COPCs:

- AOC 5 – AST Area located north of the warehouse in the vicinity of monitor wells MW-5R and MW-6R, and
- AOC 7 – Railroad Spur and Rail Loading Area, which is a former rail spur leading to the Facility from the north side of the Johnston Properties building.

3.2 RFI Investigations from 2008 to 2013

During 2008, ARCADIS conducted a comprehensive review of historical data collected during previous Site investigations to identify potential data gaps within the CSM. Data gaps that were identified included the need for additional delineation of source zones identified at the Facility, characterization of the fractured bedrock zone, definition of extents of the dissolved-phase COPCs in groundwater, and more thorough delineation of potential sources of COPCs to the Unnamed Stream. As a result, a series of additional investigations were implemented from 2008 to 2013 to fill the identified data gaps. Results from the multiple phases of investigation were presented and evaluated in the RFI Report submitted to NCDENR on September 17, 2013 (ARCADIS 2013c). Additionally, more detailed descriptions of the investigations summarized in the RFI can be found in the following references.

- Source Zone Contaminant Delineation (ARCADIS 2009)
- Bedrock Evaluation (ARCADIS 2009)
- Surface Water Investigation (ARCADIS 2010b)
- Regional Gore Module Survey (ARCADIS 2010a)
- Near Stream Soil Gas Sampling (ARCADIS 2011)
- Additional Downgradient Investigations (ARCADIS 2012)
- Off-Site Bedrock Investigation and Microcosm Sampling (ARCADIS 2013a)

The combined investigative activities conducted from 1988 to 2013 have included the advancement of 120+ soil borings; the installation of 52 permanent groundwater monitor wells; 14 temporary groundwater monitor wells; the collection of quarterly, semi-annual, and annual groundwater samples since 1994; surface water and sediment sampling from the Unnamed Stream to the southeast of the Facility; and the collection of soil gas data from 57 locations (passive and active samples). Together, these provide significant data to more fully understand the CSM for the Facility, and the Site as a whole. The updated CSM for the Site is presented in the following sections.

3.3 Conceptual Site Model

A robust CSM was developed for this Site, which provides an overview of the geologic and hydrogeologic environment, and the processes that control the fate and transport of COPCs at the Site. The full CSM is provided in the RFI (ARCADIS 2013c).

3.3.1 Hydrostratigraphic Framework

The hydrostratigraphic framework at the Site includes the saprolite, partially weathered rock (PWR) and bedrock hydrostratigraphic units (HSUs). The relationship between these units is important in understanding the distribution and transport of COPCs throughout the system.

The saprolite HSU is the result of extensive weathering of the parent bedrock. The saprolite is composed of fine grained mineral fragments including fine sand, clay, and silt. The composition increases grain size with depth and contains a high percentage of angular sand and gravel near the base of the unit where it transitions to PWR. The saprolite does not contribute significantly to lateral migration of COPCs, but is a unit for mass storage that is slowly released to groundwater through diffusion. The water that is recharged to the subsurface primarily flows vertically through the saprolite until it reaches the PWR HSU.

PWR represents a transition zone between saprolite and fractured bedrock. The PWR is less weathered than saprolite, having a greater composition of coarser grained materials such as sand, gravel, and cobbles. It can also contain larger layers or lenses of highly fractured bedrock. Groundwater percolates into this HSU from the saprolite above. The PWR has the highest permeabilities, indicating that it is a zone of potential lateral groundwater flow and mass transport.

The bedrock HSU is interconnected to the base of the PWR and also acts as a unit for mass transport; however, the bedrock is not as transmissive as the PWR and the COPC impacts are not as significant as those in the PWR. Groundwater flow in the bedrock is limited to permeable fractures, where present. The fractures' characteristics on Site are highly variable, depending on location, depth, and rock type. The presence and transport of COPCs in the bedrock HSU depends on the interconnection of fractures with the base of the PWR.

3.3.2 Surface Water Features

The Facility is located approximately 500 ft upgradient of the recharge area of the local watershed, which discharges groundwater to the Unnamed Stream. The Unnamed Stream is the primary surface water body in this area and subsequently discharges to South Buffalo Creek, approximately 1 mile south of the Facility. Historically, it extended to the railroad yard north of Patterson Street before it was filled in and converted to a municipal storm sewer system during the mid 1950s. The stream now daylights at the culvert under Immanuel Road. The Unnamed Stream receives groundwater along almost its entire length where it remains a natural stream. Groundwater flow converges on the Unnamed Stream from both sides, indicating it is a discharge boundary for groundwater migrating from either side. This is consistent with the LeGrand (2004) model for groundwater movement within the Piedmont.

3.4 Nature and Extent of Contamination

During the RFI (ARCADIS 2013c) several facilities with suspected or documented COPC impacts to soil, groundwater, or soil gas were identified within the watershed that drains to the Unnamed Stream. These facilities are depicted on **Figure 3-1** and are listed below:

- Former Chemicals and Solvents, Inc. (ChemSolv) facility. - 2804 Patterson Street;
- Tritex Chemical Corporation (Tritex) - 1200 South Holden Road;
- North Carolina Department of Transportation (NCDOT) Site #61 at the Norfolk Southern rail yard - 1124 South Holden Road;
- 1-Hour Martinizing - 2519 Highpoint Road;
- Sunset Dry Cleaners - 2615 Highpoint Road;
- Dow Corning Corp. - 2914 Patterson Street;
- ECOFLO® Inc. - 2750 Patterson Street;
- Vertellus Specialties – 2110 High Point Road;
- Sherwin-Williams - 1025 Howard Street; and
- Flint Ink - 2805 Patterson Street.

3.4.1 Ashland Source Areas

As defined by ARCADIS RFI investigations from 2008 to 2013, two source areas attributable to Ashland's former operations have been identified and delineated on the Facility and the adjacent Johnston property (2800 Patterson Street). The first is in the northwest corner of the Facility north of the existing building. The second area is located along the former rail spurs north of the Johnston Properties building. Locations of the two soil source zones on the former Ashland and Johnston Properties are depicted on **Figure 3-2.** Within this CMS the two areas are referred to as Remediation Zone A (RZ-A) and Remediation Zone B (RZ-B), respectively. RZ-A encompasses portions of SWMU 1 and AOCs 4, 5, and 7; while RZ-B in present in the eastern portion of AOC 7 and extends to the east along the rail spur (**Figure 2-1**).

RZ-A covers an approximately 5,000 square-foot area extending from the north side of the Facility building to the former tank farm along the northern property boundary. The unsaturated soil zone extends to a depth of approximately 10 ft resulting in a total remedial zone volume of 50,000 cubic feet (CF) or 1,900 cubic yards (CY). To approximate the total COPC mass in RZ-A the weight of soil within the RZ-A was estimated at approximately 3,000 tons (2.7 million [MM] kilograms [kg]) based on an expected weight of 1.6 tons per CY. This mass of soil was then multiplied by the average total COPC concentrations (1,900 milligrams per kilogram [mg/kg]) detected in all RFI soil samples collected within RZ-A from 2008 to 2013, to generate a total COPC mass estimate of 5,000 kg in RZ-A. Based on the relatively low COPC concentrations detected in soil samples outside of RZ-A, ARCADIS estimates that greater than

90 percent (%) of the COPC mass within unsaturated soil at the Facility is contained within RZ-A.

RZ-B covers an approximate 3,300 square-foot area extending from the north side of the Johnston Properties building to the northern rail spur. The unsaturated soil zone extends to a depth of approximately 10 ft resulting in a total remedial zone volume of 33,000 CF or 1,200 CY. To approximate the total COPC mass in RZ-B the weight of soil within the RZ-B was estimated at approximately 2,000 tons (1.8 MM kg) based on an expected weight of 1.6 tons per CY. This soil mass was then multiplied by the average total COPC concentrations (2,900 mg/kg) detected in all RFI soil samples collected within RZ-B from 2008 to 2013, to generate a total COPC mass estimate of 5,100 kg in RZ-B. Based on the relatively low COPC concentrations detected in soil samples on the Johnston Properties outside of RZ-B, ARCADIS estimates that greater than 95% of the COPC mass within unsaturated soil at the Johnston Property is contained within RZ-B.

The estimated combined source soil volume, soil mass, and COPC mass within the two remediation zones is 3,100 CY, 5,000 Tons (4.5 MM kg), and 10,000 kg, respectively.

3.4.2 Adjacent Off-Site Source Area

One adjacent off-Site source area was identified on the former ChemSolv facility (2804 Patterson St.) during the RFI soil investigations, which was attributable to ChemSolv's former operations. The distribution of COPCs identified in the source areas on the former ChemSolv facility were distinct from the source areas on the Facility and Johnston Property, therefore Ashland is not evaluating CMAs for the former ChemSolv sources.

3.4.3 Distribution of COCPs in Groundwater

Based on results from several lines of evidence collected during the RFI (e.g., groundwater concentrations, soil gas screening, hydraulic head directions, topography), the COPCs originating from the Facility and the Johnston Property appear to be confined within a sub-basin of the watershed depicted on **Figure 3-3** as the Eastern Migration Pathway. Groundwater COPCs from the former ChemSolv facility and other facilities to the west appear to be contained within the Western Migration Pathway that discharges to the Unnamed Stream approximately at the surface water sample location SW-5 and downstream. The approximate location of the apparent groundwater divide is depicted on **Figure 3-3** and corresponds with a broad ridgeline oriented from North to South along the western edge of the Facility that divides the Site's study area into two distinct sub-basins. This groundwater divide is used in this CMS to define the extent of groundwater attributed to Ashland's former operations.

The extent of COPCs attributable to Ashland's former operations (**Figure 3-4**) appears to be generally defined to the North by the northern property line of the Facility and the Lindley Estate; to the East by the eastern property line of the Johnston Property and the north-south oriented underground culvert south of Patterson St. that discharges to the Unnamed Stream; to the southeast by the Unnamed Stream, and to the southwest and west by the Groundwater Divide depicted on **Figure 3-3** and the western property line of the Facility.

3.4.4 Calculation of Volume of Impacted Groundwater and Mass of COCPs in Groundwater

The apparent groundwater impacts cover an area of approximately 30 acres (1,280,000 square ft) as measured from Figure 3-4 and has been detected at depths of 175 ft below land surface (bls) in groundwater collected from a packer test during installation of monitor well MW-11BR. By setting a lower bound of 180 ft bls as the total depth of the plume at the Facility and 120 ft at the Unnamed Stream (approximately 60 ft lower in elevation than MW-11BR) and 10 ft bls as the approximate top of the groundwater table, the total estimated volume of combined soil, bedrock, and groundwater media containing COPCs at concentrations above the North Carolina Administrative Code (NCAC) 2L Groundwater Standards is 187 million CF (7 million CY). Total volume of groundwater contained within the plume and total dissolved mass of COPCs in groundwater were estimated using the following assumptions:

Parameter	Estimated Value	Reference
Fluid Porosity of Saprolite	0.45	RFI soil samples analyzed for grain size and porosity
Porosity/Void Space of PWR	0.35	Daniel, Charles C. III, et.al., 1989.
Void Space of Fractured Bedrock	0.01	United States Geological Survey (USGS) 1997
Average Thickness of Saturated Saprolite Zone	21 ft	Estimated from CSM Figure 4-1 in RFI (ARCADIS 2013c)
Average Thickness of PWR	15 ft	Estimated from CSM Figure 4-1 in RFI (ARCADIS 2013c)
Average Thickness of	110 ft	Estimated from CSM Figure 4-1 in RFI

Fractured Bedrock		(ARCADIS 2013c)
Average Total COPC Concentrations in Groundwater	12.2 milligrams per liter	Data collected during semi-annual groundwater sampling in June 2014

Based on the assumptions presented in the table above, ARCADIS calculated a total volume of groundwater within the plume to be 151 million gallons (572 million liters) and a total dissolved COPC mass of 7,000 kg within groundwater.

3.4.5 Summary of Mass Estimates for COPCs in Soil and Groundwater

In summary, approximately 10,000 kg of COPC mass resides within unsaturated soil at the Site and 7,000 kg of COPC mass resides within groundwater at the site. Unsaturated COPCs are present within a 3,100 CY volume of soil (average concentration of 3.2 kg/CY) compared to dissolved COPCs present within a combined media volume of 7 million CY (average concentration of 0.001 kg/CY). Therefore, it is appropriate to prioritize corrective measures for Remediation Zones RZ-A and RZ-B as these remedial measures should achieve a much greater benefit than would active corrective measures for groundwater.

3.5 Results of the Human Health Risk Assessment

The Human Health Risk Assessment completed as part of the RFI (ARCADIS 2013c) was designed to evaluate the potential current and hypothetical future risks and hazards to human health associated with constituents detected in soil, groundwater, soil gas, and surface water samples collected at or near the Site. Maximum detected concentrations were compared to appropriate screening levels to identify COPCs for human health. Potential excess lifetime cancer risk and noncancer hazards were then calculated for the complete exposure pathways for each receptor as identified in a conceptual site exposure model (ARCADIS 2013c).

Commercial and industrial establishments and residences in the vicinity of the Site are supplied with potable water from the City of Greensboro. Further, there are no private or public water supply wells within a 1-mile radius of the Site (ARCADIS 2013b), which is an area that extends beyond Site-related groundwater impacts. Therefore, exposure to groundwater used as a potable water supply is not a complete exposure pathway at the Site; and thus, was not quantitatively evaluated. The only groundwater exposure pathway evaluated for the Site was inhalation of vapors emanating from groundwater.

The former Ashland facility and the Lindley Estate are bound by environmental covenants restricting land use to commercial and industrial purposes. Additionally, construction of subsurface structures and use of groundwater as a source of drinking water are prohibited. The Johnston Property parcel is zoned for industrial use. Deed restrictions are not currently in place for the Johnston Property parcel.

COPCs were not identified for the Lindley Estate property; therefore, it was concluded that potential risks or hazards at that property were within acceptable levels under the conditions evaluated in this risk assessment. Results indicated that potential risks and hazards to off-site resident receptors from inhalation of soil gas and from wading in the stream were also within acceptable levels. Likewise, calculated risks for current full-time workers at both the former Ashland facility and the Johnston Property were determined to be acceptable.

Calculated risks and hazards, assuming major redevelopment, for hypothetical future workers at a future building or building expansion, located in an area different than the current building, were above acceptable levels. Potential exposure to soil either through direct contact or inhalation of vapors migrating into a building was the scenario that posed the greatest potential risk. Exposure to surface soil did not pose an unacceptable risk. However, if the soil was redistributed due to excavations, then the risks were greater.

Vapor intrusion was identified at the Johnston Properties facility and is actively mitigated by continual operation of the SSD system summarized in Section 2.4.4. The SSD system installed in the building has been shown to be successfully diverting vapors in soil gas from migrating into the building (ARCADIS 2013a; **Section 3.3**). Therefore, there is currently no vapor migration exposure pathway for vapor at the Johnston Properties facility.

The vapor migration exposure pathway at the former Ashland Facility could pose a risk should the warehouse be occupied by workers on a full-time basis. Full-time occupation of the building is not expected based on its current land use. However, a potential future SSD system could be installed similar to the one constructed for the Johnston Property building, if land-use changes in the future.

3.6 Ecological Risk Assessment

A screening level ecological risk assessment was performed for the Unnamed Stream downgradient of the Site as part of the RFI (ARCADIS 2013c). No constituents of potential ecological concern (COPECs) were identified for the Unnamed Stream.

Therefore, there is adequate information to demonstrate that adverse impacts to ecological receptors from potential exposure to the surface water COPECs are not expected.

3.7 Remedial Design Data Collection Activities

ARCADIS performed several remedial design data collection activities at the Site in June 2014 to refine the remedial evaluations and assess engineering controls needed to protect building footers in areas adjacent to the remedial zones. During this work, two geotechnical borings were advanced for standard penetrometer testing (SPT) at boring locations SPT-A and SPT-B (see Figure C-1 in **Appendix C**). Blow counts were measured and soil samples were collected from these borings for Atterberg Limit testing to further evaluate soil stability and viability of a potential remedies. Boring logs and results of the Atterberg Limit tests are included in **Appendix C**.

Three borings were advanced within each remediation zone and two samples were collected from each boring for Toxicity Characteristic Leaching Procedure (TCLP) analysis for VOCs to aid in estimation of disposal costs under an excavation remedial scenario. Selected samples were also analyzed for total VOCs to estimate the average ratio of total VOC concentration to VOC/TCLP concentration. A summary of the VOC and VOC/TCLP data is presented in Table C-1 in **Appendix C** along with the laboratory data report. Results of the TCLP investigation indicated that one of the six soil samples (16%) collected in RZ-A was characteristic hazardous and two of the six soil samples (33%) collected in RZ-B were characteristic hazardous. Based on Site-specific dilution factors calculated from the data (a ratio of total COPC to TCLP COPC concentrations) and a comparison of the dilution factor to the comprehensive RFI sampling, ARCADIS estimates that the actual characteristic hazardous fraction will be greater than 33%. Conservative estimates of 50% to 66% characteristic hazardous fractions for RZ-A and RZ-B, respectively, were used in the CMA cost estimates developed later in this CMS report.

During the June 2014 investigation, samples also were collected for preliminary bench-scale testing to evaluate the viability of in situ soil solidification (ISSS) remedy as a potential CMA. Results of the ISSS bench-scale bulking test are summarized in Table C-2 and ISSS mixture strength results are summarized in Table C-3 in **Appendix C**. Results of the treatability investigation are discussed further in Section 6.2.

Lastly, in June 2014, three surface soil samples B-3R-A, B-3R-B, and B-3R-C were collected in the northeastern corner of the Facility (see Figure C-1 in **Appendix C**) where a previous soil sample B-3 collected in 1988 (T.M. Gates 1988) was reported to contain PCE at a concentration greater than the U.S. Environmental Protection Agency (USEPA) Regional Screening Levels for Industrial Soil. Results of the confirmation soil sampling are summarized in Table C-4 (**Appendix C**). No COPCs were detected in any of the three samples; therefore, no additional soil areas outside the two identified remediation zones will require corrective measures.

4. Corrective Action Objectives

This section develops the corrective action objectives that will provide the basis for evaluating the remedial alternatives that may be implemented at the Site. As provided by USEPA in the RCRA Corrective Action Plan Guidance (USEPA 1994) these objectives (also termed standards in the guidance) include:

- Protection of human health and the environment;
- Attainment of media-specific cleanup standards;
- Control the source releases to reduce or eliminate to the extent practicable, further releases that may pose a threat to human health and the environment;
- Comply with applicable standards for the management of wastes; and
- Other Factors.

In the category of Other Factors, there are five general factors that are considered, as appropriate, in selecting/approving a remedy that meets the four standards listed above. These factors represent a combination of the technical measures and management controls for addressing the environmental problems at the Site. The five general decision factors include: 1) long-term reliability and effectiveness; 2) reduction in the toxicity, mobility or volume of wastes; 3) short-term effectiveness; 4) Implementability; and 5) cost. Further detail regarding these factors is discussed in Section 5 of this document.

4.1 Areas/Media Requiring Remedial Evaluation

As presented in Sections 2 and 3, previous investigation, evaluation, and risk assessment efforts were performed for the Site and surrounding areas for soil, soil gas, surface water, and groundwater. The two source zones (i.e., Remediation Zones RZ-A and RZ-B) located north of the former Ashland building and north of the Johnston Properties building [**Figure 3-2**]) and groundwater extending from the Facility and Johnston Properties to the Unnamed Stream (see **Figure 3-4**) were selected for further remedial evaluations in the CMS. It is recognized; however, that corrective measures for source mass within Remediation Zones RZ-A and RZ-B should be prioritized.

4.2 Media Specific Clean-up Standards

The following sections present the proposed MCSs to be established as remedial goals for soil and groundwater at the Site.

4.2.1 Soil MCSs

Soil data contained in the Comprehensive RCRA Facility Investigation Report – Phase III (ARCADIS 2013c), and prior Site investigations for both the Facility and the Johnston Property, were re-evaluated to assess data from those areas with the highest COPC concentrations, which might be amenable to remediation during corrective measures implementation. The following two areas were evaluated in this assessment because they contained the largest concentrations of COPCs and the vast majority of the total COPC mass within unsaturated soil at the Site:

1. North of the former Ashland facility building in the vicinity of the former tank farm and off-loading areas (RZ-A), and

2. North of the Johnston Property building along the former railroad spurs (RZ-B).

ARCADIS evaluated the potential results of future CMAs by iteratively parsing out data from the previous Site investigations dataset used in the Human Health Risk Assessment, until a significant reduction in risk was attained. The effectiveness of these CMA scenarios was evaluated in the context of:

- Excess lifetime cancer risk (ELCR) - an estimate of the potential increased risk of cancer that results from exposure to potentially carcinogenic compounds averaged over a lifetime for constituents detected in media at the Site. USEPA considers ELCRs within and below the target risk range of 10^{-4} to 10^{-6} as potentially acceptable cancer risk (USEPA 1989). NCDENR recommends setting remedial goals so that the cumulative cancer risk (total ELCR) is less than $1{\times}10^{-4}$ (NCDENR 2013).

- Noncancer hazards are estimated by calculating the individual hazard quotient (HQ) which is the exposure dose averaged over the expected exposure period to evaluate noncancer effects. The individual HQs are added together to calculate a cumulative Hazard Index (HI). NCDENR recommends setting remedial goals so that the cumulative noncancer HI is 1 (NCDENR 2013).

The methodologies for re-evaluating each dataset and the estimated extent of each CMA are discussed below for the two source areas at the former Ashland and the Johnston Properties facilities.

4.2.1.1 Former Ashland Property

ARCADIS estimated the potential extents of the CMAs for the former Ashland Property by extracting samples from the dataset in a stepwise fashion until acceptable ECLR and HI were achieved. With removal of all samples within Remediation Zone RZ-A from the dataset, the ELCRs all fell to within or less than the USEPA target risk range, and the noncancer HIs were all below the benchmark of 1, with the exception of vapor intrusion into a building. Thus, by implementing a future CMA within the proposed RZ-A, the most reduction in risk and hazards would be achieved. This future CMA would reduce the potential for direct contact exposure with soils by a site worker as well the potential for vapor migration of constituents present in soil. Vapor intrusion is not currently considered to be an issue on the former Ashland Property because the building's tenant (Koury Corporation) uses the facility for storage of old equipment, building materials and furniture, and it is not occupied by workers on a full-time basis. Vapor intrusion concerns would be evaluated further if the occupancy of the building changes in the future.

4.2.1.2 Johnston Property

The results from the Risk Assessment (ARCADIS 2013c) indicated that PCE and toluene were the only COPCs for surface soil from 0 to 2 ft bls at the Johnson Property. Initial screening indicated that the COPCs for soil in the 0 to 9 ft bls interval were 1,2-dichlorobenzene; ethylbenzene; PCE; toluene; 1,2,4-trichlorobenzene ; 1,1,1-trichloroethane; 1,1,2-trichloroethane; TCE; and xylenes. The ELCR and HI for an industrial worker were $5x10^{-6}$ and 1 for exposure to surface soil and $7x10^{-6}$ and 17 for exposure to soil in the 0 to 9 ft bls interval. Constituents causing the risk and hazard were detected in soil within the northern area of the property (RZ-2 on **Figure 3-2**).

In order to evaluate the potential beneficial effects of a CMA for remediation zone RZ-B, risk was reassessed assuming that samples with this zone were removed from the dataset. After performing this evaluation, an ELCR could not be calculated for surface soil as no carcinogenic COPC would be present; however, the noncancer HI drops from 1 to 0.2. For exposure to soil from 0 to 9 ft bls, the ECLR drops from 7×10^{-5} to 4×10^{-6} and the HI drops from an initial 17 to 1, when the CMA activities are assumed. Thus, the risks and hazards after implementation of a CMA in these areas would be less than or equal to the regulatory benchmarks.

4.2.1.3 Combined Source Area Treatment

The developed remediation approach for the two identified source areas involves removal or treatment of all soil samples containing COPCs at concentrations greater than the NCDENR preliminary industrial health-based soil remediation goal (PSRG). The Industrial PSRGs were therefore selected as MCSs for soil. The goals of treating all soil exceeding the MCSs are: 1) to lower potential risk to hypothetical Site workers to acceptable levels, and 2) to reduce the rate of COPC leaching to groundwater which will allow COPC concentrations in groundwater to eventually achieve groundwater MCSs. Selection of more conservative MCSs (e.g., Protection of Groundwater PSRG) would do nothing to expedite groundwater cleanup, as the existing COPC concentrations within the groundwater plume are generally higher than COPCs in unsaturated soils outside the two proposed remediation zones. Additionally, any potential soil corrective measure utilized at the Site will not help to reduce groundwater concentrations on a Site-wide basis in the short-term.

Carbon tetrachloride; ethylbenzene; PCE; toluene; and 1,1,1-trichloroethane were the only constituents detected at concentrations greater than the soils MCSs in unsaturated soil at the Site; therefore these three constituents are considered to be COPCs. The identified soil COPCs along with their respective MCSs are presented on **Table 4-1.**

4.2.2 Groundwater MCSs

The MCSs for groundwater constituents at the Site are the NCAC 2L Groundwater Standards. Constituents present in the Site groundwater plume at concentrations above the groundwater MCSs are considered COPCs. The groundwater COPCs identified at the Site along with their respective MCSs are presented in **Table 4-1** and the approximate extent of groundwater above the MCSs is depicted on **Figure 3-2**.

4.2.3 Surface Water MCSs

Several target constituents were detected in the Unnamed Stream at concentrations above the NCAC 2B Surface Water Standards for Class C waters. However, a habitat assessment and a human health risk assessment were performed on the Unnamed Stream (ARCADIS 2013) and it was determined that there were no unacceptable risks to human health or the environment based on stream observations and expected stream use.

5. Corrective Measure Alternatives

The first step in the corrective measures evaluation process involves identification and initial screening of potentially applicable technologies for impacted soil and ground water including innovative treatment technologies, if applicable. The following subsections describe the remedial technologies considered for the Site.

5.1 Screened Soil Remediation Technologies

A wide array of remedial technologies to treat soils are evaluated and screened in **Table 5-1** for potential use at the Site based on reduction in overall risk to human health and the environment, effectiveness, implementability, and cost. Technologies that were retained from the screening process were assembled into CMAs for further evaluation in Section 5.4. The retained technologies were conceptually discussed with the existing property owners (i.e., Koury Corporation and Johnston Properties) to ensure their future implementability prior to selection.

5.2 Screened Groundwater Remediation Technologies

Remedial technologies for Site groundwater were evaluated and screened in **Table 5-2** for potential use at the Site based on protection of human health, effectiveness, implementability, and cost. Due to the mature nature of the plume (i.e., COPCs have migrated off the Facility, have extended deep into bedrock, have reached near steady-state concentrations in groundwater and are in near equilibrium with the non-mobile and adsorbed phases in the aquifer media), various technologies were screened out due their limited effectiveness in such conditions and/or difficulty in implementing due to the deep extents of the COPCs. Several other technologies were screened out due to implementation difficulties with respect to the large number of commercial properties and roadways in the downgradient plume area. Technologies that were retained from the screening in **Table 5-2** were assembled into CMAs for further evaluation in Section 5.5.

5.3 Developed CMAs

The second step in the corrective measures evaluation process involves assembly of the remedial technologies retained from the screening process into comprehensive CMAs for each media requiring corrective actions. The following six Soil CMAs (SCMAs) and four Groundwater CMAs (GCMAs) were assembled, and will be further evaluated in the following sections:

SCMAs

SCMA-1: No Additional Action

SCMA-2: Institutional Controls (ICs)

SCMA-3: Excavation with Off-Site Disposal and Backfill with Imported Soil

SCMA-4: Excavation with On-Site Treatment and Backfill with Treated Soil

SCMA-5: In-Situ Soil Solidification (ISSS)

SCMA-6: In-Situ Thermal Desorption (ISTD)

GCMAs

GCMA-1: No Additional Action

GCMA-2: ICs

GCMA-3: Monitored Natural Attenuation (MNA) with ICs

GCMA-4: Groundwater Recovery, Treatment, and Discharge to Surface Water, Groundwater Monitoring and ICs

5.4 Description and Evaluation of Soil Corrective Measure Alternatives

Six SCMAs were assembled from the retained remedial technologies. These SCMAs are evaluated in **Table 5-3** with respect to nine performance criteria: overall protection of human health and the environment; attainment of MCSs; control of the sources of releases; compliance with standards for the management of wastes; long term reliability and effectiveness; reduction of toxicity, mobility, or volume of waste; short-term effectiveness, implementability, and cost. The following sections summarize the design of the SCMAs presented in **Table 5-3**.

5.4.1 SCMA -1: No Additional Action Alternative

No Additional Action is considered in the corrective measures screening process as a baseline against which other alternatives are compared. No Additional Action denotes no further remedial action will take place at the Site. There are currently no complete risk pathways for exposure to Soil COPCs; and therefore, no receptor points of exposure. However, there are potential future risks to hypothetical Site workers present at the Site. Existing ICs (asphalt and concrete surface cover) would remain in place to limit potential human exposure and to limit migration of COPCs to groundwater. Additionally, the existing vapor mitigation system (i.e., the SSD system) at the Johnston Properties facility would remain operational, until a determination is made that vapor intrusion into indoor air space has been reduced to acceptable levels without the need for a mitigation system.

5.4.2 SCMA-2: Institutional Controls

ICs are those corrective actions that control land use and Site access through physical constraints, public agencies, and/or legal mechanisms. Administrative controls exist within the jurisdictions (Guilford County and NCDENR) to help ensure local conditions do not change. The ICs act to limit contact with the COPCs at the Site by restricting contact with soils at the Site or providing a barrier to preclude contact with soils. The ICs considered include:

- Land Use Restrictions – Deed restrictive covenant to compel continuation of commercial/industrial land use at the Facility and implementation of land use restrictions in the northern portion of the Johnston Properties facility.

- Inspection and Maintenance Activities – Periodic inspection of the existing RCRA Cap to confirm integrity of the barrier technology (until soil below the RCRA Cap is remediated).

- Use of an Environmental Covenant – Ashland has an agreement with the current property owners that they will contact Ashland prior to commencing any subsurface work for proper guidance on waste management and health and safety support. Further, no subsurface work is allowed under the agreement except for construction of building walls or footers.

- Notification of Change in Operating Conditions – Ashland will notify NCDENR-HWS if the operating conditions at the former Ashland Site change or if the Site owner constructs new buildings on-Site, or has new buildings on-Site occupied by indoor workers.

5.4.3 SCMA-3: Excavation with Off-Site Disposal, Backfill with Imported Soil, and ICs

SCMA-3 involves excavation of surface and subsurface soils to the approximate depth of the water table (9 to 10 ft bls), loading and hauling excavated soil to an appropriate landfill for disposal, and importing and backfilling clean soil into the excavations to meet the remedial objectives. Removing soil renders contact with soil or vapor migration from soil as an incomplete exposure pathway, thereby eliminating any potential risks to human health or the environment. A conceptual Site layout of SCMA-3 is depicted on **Figure 5-1**.

The first stage of the SCMA-3 remedy would involve completion of the final remedial design, submittal of the Remedial Implementation Work Plan, and securing all required permits for the proposed work. The next step would be to clear the remedial area of equipment and materials, demolish all asphalt and concrete structures within the remediation area, and haul demolition debris to a landfill for disposal. Once the remediation zone was cleared to the exposed soil, silt fencing, light rock cover and/or other rip rap would be placed at the Site, as necessary, to protect surface soil stability surrounding the remediation zones. The selected remedial contractor could potentially collect additional remedial design soil samples prior implementing the work to more accurately delineate the treatment area extents and/or physical properties of the soil.

An excavator would remove soil from the planned remediation zones to an approximate depth of the water table (9 to 10 ft bls) and directly load the soil into dump trucks for hauling to appropriate landfills, or other potential off-site disposal facilities. Due to the excavation depths and locations adjacent to the Site buildings, below grade structural support or a specialized excavation technique may be necessary to complete the work safely and efficiently in areas adjacent to building walls. Structural supports could include, but would not be limited to sheeting/shoring, and/or slide rail systems. Alternatively, an excavation technique could be employed that involves successive excavations and immediate backfilling of one bucket-width trenches perpendicular to the building wall. Excavation and backfilling of one trench at a time could eliminate the need for shoring or sheet-piling along the edge of the building during remedial implementation. Details of the shoring and/or excavation technique would be finalized during the remedial design phase.

After completion of the excavation and off-site hauling activities, clean imported soil would be hauled in dump trucks to the Site and backfilled in the excavation pit. Soil would be placed in approximate 2 ft lifts and compacted prior to placing subsequent layers. After sufficient compaction has been established and verified by compaction testing, the second 2-ft layer would be added and the alternating compaction and filling process could continue. On the former Ashland property, the soil would be graded to approximately 1 ft below the existing pavement grade. The top foot of the excavation pit would be filled with asphalt or concrete to match the material present prior to excavation. On the Johnston property, soil would be backfilled to the previous soil grade and seeded with grass to return the property to its original condition.

Excavation and removal of COPC-impacted soil eliminates the health concerns associated with potential exposure by hypothetical future Site workers. However, consideration also must be given to the health and safety of construction workers during implementation of the potential remedy and the risk of highway accidents during transportation of the soil to the landfill. Designated traffic routes and trucking procedures would be established prior to implementation of the remedy. On-site air monitoring and dust, vapor, and odor control provisions would be necessary during excavation operations. Exclusions zones would be established in the northern portion of the Site to limit spread of COPCs away from the remediation zones (e.g., on dump truck tires, etc.). Excavation activities may result in the release of fugitive dusts and runoff from disturbed soil. Dust controls could include water sprays or application of chemical dust suppressants. An erosion and sedimentation control plan may also be required. Current Site operations would be temporarily impacted by this remedy due to the large volume of truck traffic through the Site and the establishment of exclusion zones in the northern portion of the properties.

ICs implemented with SCMA-3 would be similar to the ICs described for SCMA-2 except that the RCRA cap would be removed and therefore future inspections and maintenance of the cap would not be required.

The overall schedule for implementing SCMA-3, from initial Site clearing activities to Site restoration, is expected to require an estimated 7- to 9-week period.

5.4.4 SCMA-4: Excavation with On-Site Treatment, Backfill with Treated Soil and ICs

Excavation of surface and subsurface soils involves physical removal of impacted soil, on-Site treatment, and backfill of treated material to achieve the remedial objectives. Typical equipment used includes excavators, front-end loaders, and an on-Site treatment system. Due to the excavation depths and locations adjacent to the Site buildings, a below grade structural support or a specialized excavation technique may be necessary to complete the work safely and efficiently. Shoring options for SCMA-4 would be similar to options discussed for SCMA-3 in the above section. A conceptual Site layout of SCMA-4 is depicted on **Figure 5-2**. If this technology was selected, then a CMS Implementation Work Plan would be developed to describe the Corrective Action Management Unit (CAMU) remediation areas and extents per the requirements of 40 Code of Federal Regulations (CFR) 264.552.

The selected on-Site treatment remedy for excavated soils is Low Temperature Thermal Desorption (LTTD). Other more long term treatment options (bioremediation and venting) were considered, but the remediation time frames for these other treatments would be long and the availability of land for larger treatment areas would be limited. The main principal behind thermal desorption of contaminated soil is a physical separation process, where contaminants and water are volatized by heating the soil. The treated soil can be reused and the pollutants, now in the gaseous phase are decomposed, filtered, washed and emitted. The end temperature of the soil is flexible but always exceeds the highest boiling point of the individual contaminants in the soil, ensuring the evaporation of all components. The vapors generated during soil treatment would need to be captured and treated before discharge to atmosphere. Design of the vapor treatment system would be finalized during the design phase and would require air permitting for discharge of the treated vapors.

All other details (Site preparation, health and safety measures, compaction, and Site restoration) of SCMA-4 would be similar to remedial design of SCMA-3 except for the following details:

- TCLP sampling would not be performed as the excavated soil would not be landfilled.
- Soil would not be hauled off-Site.
- Clean fill would not be imported.
- All excavated soil would be treated in the portable LTTD unit, sampled to confirm COPC removal and then reused as backfill.

Soil would be treated in batches, sampled to confirm that MCSs were achieved, and subsequently backfilled into the excavations. Excavation, treatment, and backfilling of COPC-impacted soil eliminate the potential human health concerns associated with soil ingestion, dermal contact and inhalation of dust and vapors. Similar to SCMA-3, consideration must be given to the health and safety of construction workers during remedial implementation, but SCMA-4 removes the risk of transportation related incidents. On-Site air monitoring and dust, vapor, and odor control provisions would be necessary during excavation operations. Excavation and treatment activities may result in the release of fugitive dusts and runoff from disturbed soil. If required, dust controls would include water sprays or application of chemical dust suppressants. An erosion and sedimentation control plan may also be required. Current Site operations would be temporarily impacted by this remedy.

ICs implemented with SCMA-4 would be similar to the ICs described for SCMA-2 except that the RCRA cap would be removed and therefore future inspections and maintenance of the cap would not be required.

The overall schedule for implementing SCMA-4, from initial Site clearing activities to Site restoration, is expected to require an estimated 9- to 10-week period.

5.4.5 SCMA-5: In-Situ Soil Solidification and ICs

The ISSS technology can be used to immobilize organic compounds in wet or dry media, using reagents to produce a stable, solidified mass. ISSS restricts contaminant migration by decreasing the surface area exposed to leaching and/or by coating the waste with low-permeability materials. Solidification is accomplished by a chemical reaction between the waste and a binding (i.e., solidifying) reagent homogenized by mechanical mixing processes. SCMA-5 would solidify all identified soils exceeding the MSCs to mitigate potential exposure pathways to hypothetical future Site workers and to significantly reduce migration of COPCs to groundwater. The implementation of this method would remove the potential for contact with impacted soil since the COPCs would be encapsulated within a concrete matrix and unavailable for contact. Similarly, rates of VOC off-gassing from the solidified mass are expected to be significantly lower than exists presently, which is expected to decrease overall vapor intrusion risks. Impacted groundwater below the buildings could however continue to be a potential source for vapor intrusion for many years regardless of source treatment effectiveness. A conceptual Site layout of SCMA-5 is depicted on **Figure 5-3**.

The ISSS method proposed for the Site is a cement-based method with a potential addition of activated carbon to enhance binding of COPCs; however, the exact composition of the binding materials would be determined during the final design phase. Typically, a Portland cement mixture would be mixed in-place in the source areas, likely with a combination of excavator bucket and excavator with a specialized rotating mixing head. Because Portland cement would be added to the soil, the final volume of treated soils would be greater than the original material volume. If the Site cannot accommodate the additional volume of soil, then a relatively small amount of treated soil may need to be transported off-Site for disposal (soil designated for off-site disposal would be from areas with lower COPC concentrations such that it could be managed as non-hazardous waste).

ISSS does not destroy COPCs, but incorporates them into a dense, homogeneous, low-porosity structure that reduces their mobility (e.g., minimizing the potential for vapor migration). Consideration must be given to the health and safety of construction workers during the excavation and in-situ mixing phases. On-site air monitoring and dust, vapor, and odor control provisions would be necessary during operations.

Due to the treatment depths and locations adjacent to the Site buildings, a below grade structural support or specialized mixing techniques may be necessary to complete the work safely and efficiently. Structural supports could include, but not limited to sheet piles or shoring. Alternatively, a mixing technique could be employed that involves successive treatment in rows perpendicular to the building wall. Using this mixing technique, alternating bucket-width rows (i.e., every other row) perpendicular to the building would be treated and allowed to cure for several days before treating the remaining rows, and could potentially eliminate the need for shoring or sheet-piling along the edge of the building during remedial implementation. Details of the shoring and/or excavation technique would be finalized during the remedial design phase.

The first stage of the SCMA-5 remedy would involve completion of the final remedial design, submittal of the CMS Implementation Work Plan, and securing all required permits for the proposed work. The selected remedial contractor could potentially collect additional remedial design soil samples prior implementing the work to more accurately delineate the treatment area extents and/or physical properties of the soil. The next step would be to clear the remedial area of equipment and materials, demolish all asphalt and concrete structures within the remediation area, and haul demolition debris to a landfill for disposal. Once the remediation zone was cleared to the exposed soil, silt fencing, light rock cover and/or other rip rap would be placed at the Site, as necessary, to protect surface soil stability surrounding the remediation zones.

ICs implemented with SCMA-5 would be similar to the ICs described for SCMA-2 except that the RCRA cap would be removed and therefore future inspections and maintenance of the cap would not be required.

SCMA-5 could be implemented without disturbing a large portion of the Site. The overall schedule for implementing SCMA-5, from initial Site clearing activities to Site restoration, is expected to require an estimated 8- to 9-week period.

5.4.6 SCMA-6: In-Situ Thermal Desorption and ICs

ISTD involves raising the soil temperature sufficiently to volatilize the COPCs, which are then removed in the vapor phase via vacuum extraction. ISTD is performed through installation of a series of heater elements (electrodes or conductive heating wells) through the extent of soil impacts. Subsurface heating causes increased volatilization of COPCs adsorbed to soil or dissolved in groundwater. Thermal conduction heating would be the method utilized at this Site due to its ability to greatly enhance media temperatures within unsaturated soil zones, which is where the majority of COPC mass resides at the Site. Using this treatment method, soil temperatures may be increased up to approximately 250ºF, which would enhance VOC extraction and removal from the Site. A conceptual Site layout of SCMA-6 is depicted on **Figure 5-4**.

ISTD treatment could increase vapor intrusion risks into adjacent buildings; therefore, monitoring and additional vapor intrusion mitigation efforts may be necessary at the Site during implementation of SCMA-6.

Site preparation activities would include clearing the two remediation zones of all materials, equipment, and above-ground structures. Unlike the previous CMAs, the asphalt and concrete surface at the former Ashland Facility could remain intact. The heating and vapor extraction wells would be installed through the asphalt and concrete layers in RZ-A. Low-permeability barriers would be placed on the surface of the exposed soil at RZ-B to help ensure that the majority of the volatilized COPCs are captured by the vacuum extraction wells, and to improve thermal efficiency by minimize heat losses through the surface of the treatment zone. Because SCMA-6 would not require significant earthwork or removal of the asphalt and concrete surface cover, the Site restoration requirements would be much less that the other active SCMAs.

Extracted soil vapors would be treated on-Site with granulated activated carbon (GAC) filters prior to discharge to the atmosphere. The treatment and discharge of vapors would require air permitting prior to implementation of the remedy and would require periodic sampling of the vapor effluent. The GAC filters would require periodic replacement and transport off-Site for proper treatment of the GAC medium. Sampling of soils within the treatment zones would be conducted during and at completion of the remedy to confirm that MCSs had been achieved at the Site.

Consideration must be given to the health and safety of construction workers during installation and operation of the ISTD system, and protection of buildings and other subgrade structures and utilities present on site. The ISTD system would be electrically powered, and could possibly require upgrades to the electrical supply to the Site. The potential for electrical hazards would be mitigated by the implementation of a conservative health and safety program. Specialized contractors and operators would be required to construct and operate the ISTD system that would have substantial prior experiences and applicable training (i.e., Electrical Safety Training, Lockout/Tagout, and ARC Flash). Also, the ISTD treatment areas would be isolated and secured to exclude general construction workers from the electrically classified areas.

ICs implemented with SCMA-6 would be similar to the ICs described for SCMA-2 except that the RCRA cap would no longer be necessary and therefore future inspections and maintenance of the cap would not be required.

The ISTD system could be installed within a 2- to 3-month period, but might operate for up to a 1-year period before achieving the MCSs in the two source zones. As a result, the expected remedial timeframe for ISTD would be significantly longer than the other CMAs evaluated.

5.5 Description of Corrective Measure Alternatives for Groundwater

Four GCMAs were assembled from the retained remedial technologies. These GCMAs are evaluated in **Table 5-4** with respect to nine performance criteria: overall protection of human health and the environment; attainment of MCSs; control of the sources of releases; compliance with standards for the management of wastes; long term reliability and effectiveness; reduction of toxicity, mobility, or volume of waste; short-term effectiveness, implementability, and cost. The following sections summarize the design of the GCMAs presented in **Table 5-4**.

5.5.1 GCMA-1: No Additional Action Alternative

No Action is considered in the corrective measures screening process as a baseline against which other technologies and later alternatives will be compared. No Additional Action denotes no additional remedial actions would take place at the Site. COPC concentrations in groundwater are currently above the NCAC 2L groundwater standards and therefore No Additional Action is not a viable remedial technology. However, it was retained in the screening process as a baseline for comparison with the other technologies.

5.5.2 GCMA-2: Institutional Controls

ICs are those corrective actions that control groundwater use and Site access through physical constraints, public agencies, and/or legal mechanisms. The ICs considered for groundwater include:

- Restrictive covenants exist for the former Ashland facility to restrict:
    - the property to non-residential use and exclude hospitals, nursing homes, day care facilities, and other sensitive communities;
    - the installation of subsurface structures (excluding building and/or support footers after proper notification to Ashland and NCDENR), and
    - the use of groundwater beneath the facility as source of drinking water.
- There are currently no groundwater supply wells located within 1,500 ft of the Site and all properties in this area are connected to the City water supply. Administrative controls exist within the local jurisdictions (Guilford County and NCDENR) to help ensure this condition does not change.

5.5.3 GCMA-3: Monitored Natural Attenuation and ICs

Attenuation of the residual COPCs in groundwater will continue over time through several natural attenuation mechanisms. Natural attenuation mechanisms identified at the Site include advection, dispersion, sorption, dilution, biodegradation and volatilization to soil gas with eventual release to atmosphere and subsequent photo-degradation. The most significant biodegradation attenuation mechanism for COPCs in groundwater appears to be reductive dechlorination, based on the presence of PCE degradation compounds (e.g., TCE and cis-1,2-dichloroethene) in downgradient groundwater.

Under the MNA remedial technology, COPC concentrations in groundwater would be monitored periodically to document and evaluate decreases over time and to confirm the reduction in the overall extent of the COPC impacts. The Site currently has an extensive well network capable of monitoring groundwater concentrations across the majority of the plume. Further, groundwater at the Site discharges to the Unnamed

Stream located south of the Site and COPCs in groundwater from the Site have not been observed to be crossing this discharge boundary. The groundwater monitoring plan for GCMA-3 is presented on **Table 5-5**, and a layout of the proposed wells is depicted on **Figure 5-5**. Based on the proposed sampling plan, 20 wells would be sampled annually for laboratory analysis of VOCs and 5 wells would additionally be sampled for semi-volatile organic compounds (SVOCs).

There are currently no unacceptable risks to human health or the environment due to groundwater COPCs but ICs would be implemented to prevent the potential development of risk pathways (e.g., installation of water-supply wells, construction or maintenance activities that would involve excavation to the water table) within the extent of the known groundwater plume extending from the Facility to the Unnamed Stream. ICs implemented with GCMA -3 would be identical to the ICs described for GCMA-2.

When combined with a soil remedy to reduce future migration of COPCs from soil to groundwater, GCMA-3 would achieve MCSs at the Site over a long timeframe.

5.5.4 GCMA-4: Groundwater Recovery, Treatment and Discharge to Surface Water and ICs

In Alternative GCMA-4, groundwater extraction wells would be installed to create a hydraulic barrier to reduce COPC migration to the Unnamed Creek. There are very few vacant areas in downgradient portions of the plume; and therefore, the locations of the potential recovery wells and treatment system likely would be limited to those areas (likely in vicinity of the railroad right-of-way south of Patterson St.). A conceptual layout of potential groundwater recovery well locations and treatment system building location are presented on **Figure 5-6**. The preliminary design of the extraction system includes installation of five recovery wells screened in the shallow saprolite to PWR aquifer zone (total depth approximately 30 ft bls) and five wells screened within the deeper PWR to fractured bedrock aquifer zone (total depth approximately 65 ft bls). Recovery wells would be located within undeveloped areas in the northern portions of several properties along the northern side of Immanuel Road. Property owner permission would be required to install these wells and issues concerning piping below existing roads or railroad tracks may render some system configurations unpractical to implement; therefore, the exact locations may be modified based on potential future access agreements. Recovered groundwater would be pumped to a treatment building and treated by air stripping and GAC filtration, followed by discharge to the Unnamed Creek. Discharge of treated groundwater to surface water would require National Pollution Discharge Elimination System (NPDES) permitting and periodic sampling of influent and effluent to confirm permit conditions will be met. Discharge to surface water would likely be required as the City of Greensboro has strict limits on the discharge of treated groundwater to the City sewer system.

There are currently no unacceptable risks to human health or the environment due to groundwater COPCs but ICs are in place with the local jurisdictions (i.e., City of Greensboro and Guilford County Health Department) to minimize the potential for installing water supply wells.

GCMA-4 would require frequent operation and maintenance visits to monitor system performance, maintain and clean equipment, sample influent and effluent, and to periodically change out the GAC filters. Expected effectiveness of GCMA-4 is uncertain and likely would have moderate effectiveness at best. Capturing all impacted groundwater with any reasonably constructed groundwater extraction system is highly unlikely.

5.6 Evaluation Criteria

Each of the assembled CMAs were evaluated for their ability to comply with four performance standards and five balancing factors (USEPA 1991). The performance standards and balancing factors are listed below and discussed in the following sections.

Performance Standards:

- Protect Human Health and the Environment
- Attain MCSs
- Control the Source of Releases
- Comply with Applicable Standards for the Management of Wastes

Balancing Factors:

- Long-term reliability and effectiveness
- Reduction of toxicity, mobility, or volume of wastes
- Short-term effectiveness
- Implementability
- Cost

5.6.1 Protect Human Health and the Environment

This criterion relates to how the alternative provides protection to human health in addition to how it protects the flora and fauna of the environment. Included in this criterion is a relative measure of risk associated with a given remedy. Evaluation of the overall protectiveness of an alternative focuses on whether a specific alternative provides adequate protection and describes how risks associated with the potential Site-specific exposure pathways are eliminated, reduced, or controlled through treatment, engineering, and/or land use controls. This evaluation criterion also allows for consideration of whether an alternative poses any unacceptable short-term (during remedial activities) or cross-media impacts.

5.6.2 Attain MCSs

This criterion is evaluated on the ability of a CMA to achieve MCSs at the Site that are medium- and constituent-specific. Development of the MCSs was detailed in Section 4 of this report.

5.6.3 Control the Source of Releases

Continued release of COPCs may have a prolonged effect that causes a selected remedy to be ineffective or less efficient to achieve cleanup. Controlling releases is not confined to addressing mechanisms or procedures performed at the Site, but also relates to subsurface conditions. For example, impacted soil may present a potential continuing release of COPCs to groundwater. This criterion is used to evaluate how a CMA reduces or eliminates further releases at the Site.

5.6.4 Comply with Applicable Standards for the Management of Wastes

This criterion evaluates how a CMA would be implemented to manage wastes associated with remediation in accordance with all Local, State and Federal regulations.

5.6.5 Long-Term Reliability and Effectiveness

The evaluation of alternatives under this criterion addresses the results of a remedial action in terms of the potential exposure risk remaining at the Site after corrective measures objectives have been satisfied. Each alternative must be assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will be successful.

Consideration should be given to residual risk remaining from treatment residuals and/or untreated constituents at the conclusion of remedial activities and the requirement of a 5-year review. In addition, the evaluation should include an assessment of the adequacy and reliability of remedial controls, if any, that are used to manage treatment residuals or untreated constituents remaining at the Site.

5.6.6 Reduction in Toxicity, Mobility, or Volume of Wastes

This criterion is used to evaluate each CMA's ability to reduce mobility, toxicity, and/or volume of the COPCs in the media as their principal element. Reductions in mobility can be achieved through solidifying soils, creating low-permeability barriers, disposal of impacted soils in a landfill, or creating a hydraulic barrier to prevent groundwater migration away from a property. Reductions in toxicity can be achieved through chemical breakdown (e.g., oxidation and reduction reactions) of the COPCs into less- or non-toxic compounds. Reductions in volume of waste could be completed by extracting COPCs from one media and condensing into another (i.e., stripping COPCs from impacted media and condensing in an activated carbon filter or by complete degradation of COPCs within a volume of media).

5.6.7 Short-Term Effectiveness

This evaluation criterion addresses any benefits and/or risks to human health or the environment that a CMA creates during construction, implementation, and operational phases of remedial action until remedial objectives are achieved. Under this criterion, the CMAs are evaluated with respect to protection of the community and of workers during remedial action, and the degree of environmental impact as a result of remedial actions already performed.

5.6.8 Implementability

The implementability evaluation is used to determine the ability to construct and operate the technology reliably with regard to technical practicability; ability to monitor effectiveness; availability of off-Site services if needed; and coordination and acceptance of regulators, property owners, and the community.

5.6.9 Cost

The cost criterion addresses the capital costs and annual operation and maintenance (O&M) costs. Costs are estimates for the scope of the remedial action described. Present day costs were used in the calculation of the CMA costs rather than a present-worth analysis using a future discount factor. Costs are presented for comparison and evaluation purposes, and assumptions are the same for all chosen alternatives (i.e., treatment volumes and equipment/labor rates).

5.6.10 Other Remedy-Selection Considerations

Ashland embraces the practice of sustainable remediation principles. Incorporating approaches to remediation that will not only achieve corrective measure objectives but also provide benefit to the environment. Where possible, the following have been considered in the CMA evaluation process:

- Minimize energy consumption, or the consumption of other natural resources such as land, water, or landfill space;
- Reduce COPC transfer to other phases (e.g., VI, off-site disposal of impacted media);
- Natural processes (e.g., MNA, in situ bioremediation)
- Minimize the generation of waste products as a result of remediation, recycling or reusing these process streams where possible; and
- Encourage the selection of remedial technologies that permanently destroy or minimize the potential for migration of COPCs.
- Nuisance, odor and additional traffic impacts on the surrounding community.

5.7 Evaluation of Corrective Action Alternatives

The CMAs for soil and groundwater were assessed against the nine evaluation criteria (detailed in Section 5.6) in **Tables 5-3** and **5-4,** respectively. At this Site, there is currently no complete exposure pathway for soil or groundwater and no unacceptable human health or environmental risk from surface water. Additionally, there is limited potential for human health or environmental risks under reasonably anticipated future land use. The absence of unacceptable risk is an important factor to be considered when evaluating treatment methods, time to treatment, and remedy selection. Summaries of the detailed evaluations for SCMAs presented in **Table 5-3** are included in the following sections.

5.7.1 Summary of SCMA Evaluations

5.7.1.1 SCMA-1: No Additional Action

The No Additional Action (SCMA-1) alternative is not protective of human health and the environment than existing conditions (which currently have no complete exposure pathways) as it does not prevent potential risk pathways nor reduce migration of COPCs from soil to groundwater. SCMA-1 would not achieve MCSs for Site soil nor control releases of COPCs from soil to groundwater. SCMA-1 would comply with standards for waste management as no waste would be produced. SCMA-1 would not be reliable or effective technology because it would not reduce mobility, toxicity, or volume of COPCs in soil. Therefore, the No Additional Action alternative would not be an acceptable CMA for the Site.

5.7.1.2 SCMA-2: Institutional Controls

ICs would be implemented at the Site to protect human health by limiting the potential for exposure. Implementation of the ICs would reduce the potential for human contact with COPCs in the subsurface. ICs would be protective of the environment as the presence of COPCs in Site soil and the continuing migration of COPCs to groundwater do not appear to be impacting any sensitive ecosystems. The implementation of ICs alone would not achieve the soil MCSs, and therefore, should be combined with other technologies.

ICs would be reliable for as long as they are maintained; and thus, a 5-year review period is typically recommended to help ensure they remain protective. SCMA-2 would not reduce mobility, toxicity, or volume of COPCs in soil. There would be no short term risks associated with SCMA-2, it would be technically implementable and administratively feasible as long as property owners agree to the ICs. ICs are already in place for the Koury Corporation (former Ashland) Property and the former Lindley Estate property. Ashland will pursue discussions with the management at the Johnston Properties facility to develop a pathway forward for obtaining ICs for their facility. Costs associated with SCMA-2 are low as the remedy has no active monitoring or remediation components.

Conclusions of the evaluation are that while SCMA-2 is protective of human health, it would not reduce or control COPC concentrations and would not be an acceptable stand-alone remedy for the Site. Overall 30-year costs for SCMA-2 are presented in Table D-1 in **Appendix D** and estimated to total $46,000.

5.7.1.3   SCMA-3: Excavation with Off-Site Disposal and Backfill with Imported Soil and ICs

With SCMA-3, soils would be excavated within source areas and disposed off-site. Clean, imported soil would replace the excavated soils. Excavation would be protective of both human health and the environment as COPCs are removed from Site soils and disposed of in a secure landfill; therefore, there would be no completed exposure pathway for soils once SCMA-3 was implemented and completed. SCMA-3 would achieve the MSCs for soils at the Site and would minimize the continuing COPC releases to groundwater within a short time frame. During implementation of SCMA-3, remediation practitioners would comply with the standards for health and safety and handling waste. The excavated soils would be tested and disposed in an appropriate landfill based on characterization of the wastes.

SCMA-3 would provide long term reliability and effectiveness as COPCs are permanently removed from the Site. SCMA-3 would reduce mobility of COPCs at the Site as the soil would be transferred to a secure landfill; however, toxicity and volume of the soil containing COPCs would not be reduced as impacts would be just transferred to another location. SCMA-3 would introduce extra traffic to the area surrounding the Site and large volumes of contaminated soil would be transported through the surrounding neighborhood. These actions would increase short-term risks to Site workers, truckers and the surrounding community; however, such risks would be somewhat mitigated through implementation of health and safety measures including monitoring, exclusions zones, traffic control plans, lined and/or covered trucks or containers and other protective measures. In addition to some manageable short-term risks, SCMA-3 would also provide short-term benefits to the Site.

SCMA-3 is implementable; however, portions of the excavations would be adjacent to the facilities' buildings and would require additional evaluation, specialized excavation techniques, and/or shoring of the excavation to prevent damage to building foundations. SCMA-3 would impact current Facility operations and would limit access to the Facility while active remediation was being performed.

Corrective Action Management Unit (CAMU) rules applied to RCRA waste specify that any excavated soil that is placed on ground surface would need to be permitted and would need to conform to CAMU requirements which could be very onerous to implement during excavation activities. To avoid the CAMU permitting and Site requirements, excavated soil would need to be directly loaded into roll-off boxes and stored at the Facility for a few days until results from laboratory testing could be received for hazardous determination. Due to the limited space at the facility, this requirement may severely limit the rate at which soil can be excavated which could lead to longer remediation timeframes and higher costs.

Overall costs for SCMA-3 are presented in Table D-1 in **Appendix D** and are estimated to be $2,100,000. Costs for SCMA-3 are generally high and could vary greatly depending on the characterization of excavated soil as hazardous or non-hazardous and the potential that the excavation volume will increase based on confirmatory sampling results from excavation walls.

5.7.1.4 SCMA-4: Excavation with On-Site Treatment and Backfill with Treated Soil and ICs

With SCMA-4, soils would be excavated from the two source areas, treated on Site to remove COPCs, and returned to the excavation as clean backfill. Excavation with on-Site treatment would be protective of both human health and the environment as COPCs are removed from Site soils and destroyed or captured in GAC filters for subsequent treatment. Thus, potential exposures with constituents in soils would be minimized. SCMA-4 would achieve MSCs for soils at the Site and would control the source of continuing COPC release to groundwater within a short time frame. SCMA-4 would comply with the standards for handling waste as the treatment system would be fully permitted and GAC containing COPCs would be regenerated in accordance with industry standards.

Like SCMA-3, SCMA-4 would provide long-term reliability and effectiveness as the COPCs within the remediation zones would be permanently removed from the Site. Mobility, toxicity, and volume of waste would be reduced as COPCs would be extracted from soils and destroyed in the on-Site treatment process or stored on GAC and destroyed at an off-Site treatment facility during GAC regeneration. This remedy has moderate short term risks for Site workers during excavation and treatment operations. However, Site risks would be mitigated by implementing Site health and safety measures. Additionally, there would be much less traffic through the community compared to SCMA-3. This remedy would have short-term benefits to the Site, however it would require additional time to complete compared to SCMA-3 and would occupy a larger portion of the Site to complete treatment operations.

Implementation of excavation with on-Site treatment and backfill would be more difficult to implement than most CMAs, as it would be disruptive to a larger area of the Site, the excavations would need to remain open during treatment operations, it would require longer time to complete than most CMAs, and there could be difficulties in obtaining permits for on-Site treatment of waste and discharge of treated vapors to the atmosphere.

To avoid the CAMU permitting and Site requirements discussed in the previous section, SCMA-4 also would require that soils are excavated and directly loaded into roll-off boxes. Similar to SCMA-3, this requirement could lead to longer remediation timeframes and higher costs due to the limited availability of storage space at the Facility.

Overall costs for SCMA-4 are presented in Table D-1 in **Appendix D** and are estimated to be $1,900,000. Costs would be slightly lower and have less uncertainty than SCMA-3 but higher than SCMA-5 evaluated below.

5.7.1.5   SCMA-5: In-Situ Stabilization and Solidification (ISSS) and ICs

With SCMA-5, Site soils would be engineered into a low permeability monolith which would significantly reduce potential exposure pathways to Site workers and reduce migration of COPCs to groundwater; thereby SCMA-5 would be protective of human health and the environment. The potential for exposure with soil would be eliminated since any COPCs present in the soil would be trapped in the monolith and contact could not occur under normal Site activities permitted under the implemented ICs. Further, in the event that human contact with the solidified monolith did occur, the COPCs would be bound within a low-permeability concrete matrix, effectively eliminating any potential exposure via the dermal or ingestion pathways. Additionally, the potential for vapor migration from soil to indoor air would be significantly reduced because the VOC off-gassing from the monolith would be greatly reduced from existing conditions.

SCMA-5 would attain the MCSs and control the sources by encapsulating all soil containing COPCs at concentrations greater than the MCSs. SCMA-5 would comply with standards for waste management as little to no waste would be generated. In the event that the Site could not accommodate the additional soil volume (due to expansion), then the residual non-hazardous soils would be hauled off the Site and disposed at a landfill in accordance with industry standards.

Implementation of SCMA-5 would provide long-term reliability and effectiveness as the low-permeability monolith is expected to remain intact over a long timeframe. Mobility of COPCs will be significantly reduced with SCMA-5, which should also substantially diminish the rate of COPCs leaching into groundwater, thereby lowering COPC concentrations in groundwater. However, toxicity and volume of the monolithic structure would not be reduced because the COPCs would still exist, but would be encased within a concrete matrix. SCMA-5 would be completed in a short timeframe; and therefore, would have high short-term effectiveness. SCMA-5 would also have lower short-term risks as soil would remain in place and would not be trucked through the community. The short term risks during construction would be mitigated by implementation of health and safety measures.

ARCADIS collected preliminary soil samples and performed bench-scale treatability tests. Results of the treatability tests indicated that the soil at the Site would be amenable to the ISSS technology and therefore SCMA-5 is deemed highly implementable. If required, additional soil testing could be conducted during the design phase to refine the remedial approach prior to implementation. Additionally, during performance of the remedy, samples of the solidified soil will be collected and analyzed to assess that the performance standards for hardness and reduced COPC leaching have been achieved.

Overall costs for SCMA-5 are presented in Table D-1 in **Appendix D** and are estimated to be $930,000. SCMA-5 has lower costs than the other active remedies and is less subject to cost variability. Other benefits of SCMA-5 include: less energy usage than other active remedies, and little to no landfill loading compared to SCMA-3.

5.7.1.6 SCMA-6: In-Situ Thermal Desorption and ICs

With SCMA-6, soil within the two remediation zones would be heated to volatilize COPCs and SVE wells would remove COPCs thereby reducing potential exposure to Site workers and preventing migration of COPCs from soil to groundwater. By removing the COPCs from soil, any future contact with soil would not result in adverse health effects since the COPCs would have been removed. Similarly, the potential for vapor migration of COPCs from soil to indoor air would be significantly reduced by removing the COPCs from the subsurface soil.

Extracted vapor containing COPCs would be treated on-Site, which would require air permitting. The treatment system would include GAC treatment which would require off-Site disposal or regeneration. Additionally, a significant volume of liquid condensate may form which would also require treatment and potential discharge to surface water (including NPDES permitting). All wastes would be appropriately handled in accordance with industry standards. ISTD would achieve the MCSs within approximately 1 year. Very little additional traffic would be introduced in the area surrounding the Site.

By removing COPCs from the Site, SCMA-6 would be protective of both human health and the environment, would attain MCSs for soil and would control the source of continuing release to groundwater. SCMA-6 would comply with the standards for handling waste as the treatment system would be fully permitted and GAC containing COPCs would be regenerated in accordance with industry standards.

SCMA-4 would provide long-term reliability and effectiveness as the COPCs within the remediation zones would be permanently removed from the Site. Mobility, toxicity, and volume of waste would be reduced as COPCs would be extracted from soils and destroyed in the on-Site treatment process or stored on GAC and destroyed at an off-Site treatment facility during GAC regeneration. This remedy has moderate short term risks for Site workers during system operation due to the high voltage electrical component of the system, but risks would be mitigated by implementing appropriate health and safety measures. This may pose a risk to buildings and other underground structures or utilities, which would have to be mitigated during the design and implementation of this remedy. This remedy would achieve remedial goals after approximately 8 to 12 months which would be significantly longer than the other SCMAs.

Overall costs for SCMA-6 are presented in Table D-1 in **Appendix D** and are estimated to be $4,100,000. Costs for SCMA-6 are extremely high compared with other viable SCMAs.

5.7.2 Groundwater Corrective Measure Alternatives (GCMAs)

Summaries of the detailed evaluations for GCMAs presented in **Table 5-4** are included in the following sections.

5.7.2.1 GCMA-1: No Action

This alternative is not considered because substantial attenuation of COPCs in groundwater is already occurring at the Site. As such, it is not practical to evaluate the No Action alternative in the absence of ongoing natural attenuation. Also, the No

Action alternative (alone) would not include periodic monitoring and reporting to confirm that the MCSs are eventually achieved.

5.7.2.2 GCMA-2: Institutional Controls

With GCMA 2, ICs would be implemented at the Site to protect human health and the environment by managing and mitigating exposure to groundwater exceeding the MCSs. ICs (e.g., deed restrictions) already exist for the Koury Corporation and former Lindley Estate properties. Ashland will pursue discussions with the management at the Johnston Properties facility to develop a pathway forward for obtaining ICs for their facility. Additional relevant ICs include:

- Guilford County Well Rules (Effective July 1, 2008) require all well contractors and pump installers to be registered with the Guilford County Health Department, certified with the State of North Carolina in accordance with 15A NCAC 27, and abide by applicable state and county regulations prior to and during well construction activities.

- Well construction permits are required by Guilford County prior to construction to enable a field investigation to identify potential sources of groundwater contamination on or around the property on which a water well is to be located. Governmental agencies would maintain these records, which should minimize the potential for issuance of well permits within the vicinity of Site.

Conclusions of the evaluation are that while GCMA-2 alone would be protective of human health and the environment, attenuation of COPCs in groundwater would not be monitored or documented to confirm that MCSs are achieved. Therefore, ICs would need to be combined with other technologies in order to be effective. Overall 30-year costs for GCMA-2 are presented in Table D-2 in **Appendix D** and estimated to total $46,000.

5.7.2.3 GCMA-3: Monitored Natural Attenuation and ICs

With GCMA 3, ICs would be implemented at the Site to manage and mitigate exposure to groundwater exceeding MCSs. The ICs implemented would be identical to ICs implemented for GCMA-2 as detailed in Section 5.7.2.2. In addition to ICs, COPC concentrations in groundwater would be monitored periodically to confirm that natural attenuation of COPCs was proceeding and surface water in the Unnamed Creek would be monitored to confirm that groundwater discharge to surface water was not resulting in COPC concentrations that could cause unacceptable risk to potential stream waders.

Conclusions of the evaluation are that GCMA-3, when combined with an active soil remedy would be protective of human health and the environment and would achieve MCSs over a long time period. The selected soil remedy would control the source of continuing releases to groundwater, which would allow natural attenuation mechanisms to degrade the COPCs over time. The activities required for GCMA-3 have effectively been performed at the Site and under GCMA-3, waste handling would continue to comply with industry standards.

GCMA-3, when combined with an active soil remedy would have long term reliability and effectiveness and would reduce toxicity and volume of COPCs in groundwater over time. GCMA-3 would be protective of human health in the short term and would have no additional short terms risks and no implementation difficulties. Overall 30-year costs for GCMA-3 are estimated to be $620,000 and are detailed in Table D-2 in **Appendix D**.

5.7.2.4 GCMA-4: Groundwater Recovery, Treatment, and Discharge to Surface Water and ICs

GCMA-4 combines the ICs in GCMA-2 and monitored natural attenuation in GCMA-3 with groundwater recovery in the downgradient plume area to create a hydraulic barrier to limit COPC migration. The ICs would be identical to those implemented for GCMA-2 as detailed in Section 5.7.2.2. Groundwater monitoring would also be performed to confirm the nature and extent of COPCs over time. Surface water in the Unnamed Creek also would be monitored to confirm that groundwater discharge to surface water was not resulting in COPC concentrations that could cause unacceptable risk to potential stream waders.

Conclusions of the evaluation are that GCMA-4, when combined with an active soil remedy would be protective of human health and the environment and achieve MCSs over a long time period. However, the rates of COPC mass removal by groundwater recovery systems typically decrease significantly over time; and therefore, GCMA-4 likely would not achieve the MCSs for groundwater any sooner than GCMA-3. The effectiveness of GCMA-4 would likely be constrained by the existing Site conditions (Site is highly developed with limited access and hydrogeologic conditions are not conducive to groundwater extraction). The selected soil remedy would minimize continuing releases to groundwater, allowing for natural attenuation mechanisms to degrade the COPCs over time. Recovered groundwater would be treated in compliance with industry standards and would be discharged to the Unnamed Stream. This would require NPDES permitting and periodic sampling to confirm the permit conditions would be met.

GCMA-4, when combined with an active soil remedy would have long term reliability as long as the extraction system is maintained and would reduce mobility of COPCs in the short term and toxicity and volume of COPCs over time, mostly through natural attenuation mechanisms. Overall effectiveness of GCMA-4 is uncertain based on the complex hydrogeological conditions and limited land areas for construction of wells and piping systems, which would limit the ability to capture all COPCs in groundwater. GCMA-4 would have similar protection of human health as GCMA-3 in the short term but would have greater short terms risks related to recovery well installations, and constructing the treatment system and piping runs. GCMA-4 would be very difficult to implement as land would need to be secured for the treatment building on private or City of Greensboro property, a NPDES permit would be needed for discharge of treated water, and installation of the recovery wells and treatment system may be difficult among the closely spaced commercial buildings and roadways in the downgradient plume area. Construction disruptions and noise levels near residential areas may also add to implementation difficulties and lowered community acceptance of the remedy. Further, pending construction area accessibility and final system layout, there could be sections of system piping that would need to be installed below existing roadways or existing railroad tracks which would greatly add to implementation difficulties and drive up costs.

Groundwater recovery may help control the migration of COPCs in groundwater; however, continuing off-Site sources of COPCs (e.g., former ChemSolv, NCDOT, Dow Chemical, and various drycleaners) may be drawn toward the recovery wells due to altered groundwater surface contours. These off-Site sources of COPCs would also continue to be discharged to surface water regardless of any potential groundwater remedy implemented at the Site.

GCMA-4 would reduce mobility of Site COPCs by creating a partial barrier to groundwater flow to the Unnamed Stream, but may exacerbate mobility of off-Site COPCs by drawing them toward the Unnamed Creek. Due to the deep nature of COPC impacts, a complete barrier to COPC migration likely would not be established by any reasonably-constructed recovery system.

GCMA-4 would have extremely high long term costs and would provide little benefit in comparison to GCMA-3 (MNA and ICs). Estimated costs would be $5,800,000 over a 30-year period as presented in Table D-2 in **Appendix D**.

6. Justification and Recommendation of the Corrective Measures

6.1 Selected Soil Corrective Measure

SCMA-5 (*In-Situ* Soil Solidification and ICs) is recommended as the preferred soil remedy for the Site. This treatment alternative acts to contain the COPCs in a solidified monolith with low hydraulic and pneumatic permeability, preventing potential human exposure pathways via dermal or ingestion pathways as well as trapping the volatile COPCs within the structure to minimize the potential for vapor migration from the source area to indoor air. In addition to the active soil remedy and ICs to protect human health, groundwater monitoring would be conducted near the remediation zones to document decreases in COPC migration and subsequent COPC attenuation over a long timeframe. Decreasing groundwater concentrations over a long timeframe would indicate that migration of COPCs from soil to groundwater was reduced and would confirm remedial effectiveness. The monitoring to confirm effectiveness of the soil remedy would be conducted as part of the groundwater remedy detailed in Section 6.2. Costs for the groundwater monitoring are included within the costs for the selected groundwater remedy. Effectiveness of the remedy would be reviewed every 5-years after implementation.

The purchase agreement between Ashland and Koury Corp limits the future development of the Koury property and limits future excavation of soils in the northern portion of the property except for construction of footings for an expansion of the existing building or other shallow excavations for which Ashland has granted written approval and which are not expected to impact baseline environmental conditions. Implementation of ISSS at the Koury property is not expected to significantly change these conditions or the ability to excavate and construct potential future building footings within the solidified soil areas. Safety considerations regarding potential future excavation activities and handling of soil would not change after implementation of ISSS; Koury Corp would continue to be required to include Ashland's input and approval in all such planned earthwork activities. Further, the future solidified soil would have lower permeability and higher compressive strength than the existing soil. Ashland and NCDENR would need to be consulted and provide their written approvals for any planned future excavations or construction activities within the ISSS remediation zone.

Implementation of SCMA-5 is expected to decrease future vapor intrusion into the Johnston Properties building and may decrease indoor air concentrations to acceptable levels over time; however, COPC off-gassing from groundwater may continue to be a vapor intrusion issue. Indoor air quality would be monitored periodically during temporary SSD deactivation events to assess the continued need for the SSD system. Pending favorable future indoor air quality improvements within the Johnston Properties building, Ashland may request that the SSD system be deactivated and that indoor air monitoring events be decreased in scale and frequency. The SSD infrastructure would likely remain in place in the event that any rebounding indoor air quality issues arise.

With SCMA-5, the existing RCRA cap at the Koury Corp property would be removed to allow for implementation of the ISSS treatment. During Site restoration, the entire remediation area on the Koury Corp property would be paved. Because the entire unsaturated source soil zone would be solidified and permeability greatly reduced, there would be no further need for the RCRA cap; therefore, the currently-implemented periodic RCRA cap inspections would cease after completion of SCMA-5.

The surface of the source area at the Johnston Property is currently exposed soil with grass cover. After solidification of the source zone on this property, the area would be covered with a layer of clean topsoil and re-seeded with grass. This would minimize the potential for Site workers to contact COPCs in the soil since the treated soil would be encapsulated within a concrete matrix.

Advantages of SCMA-5 and reasons for selection of SCMA-5 as the preferred remedy include the following:

- SCMA-5 performs well when evaluated against each of the nine screening criteria and performed well in the preliminary bench-scale tests.

- SCMA-5 encapsulates the COPCs within a low permeability monolith, which reduces potential exposure to Site workers and significantly reduces migration of COPCs to groundwater.

- SCMA-5 would have high short-term effectiveness. Remedial goals would be met within approximately 2 months and disruption of Facility operations would be lowest of all the CMAs.

- SCMA-5 would be more cost effective than other active remedies.

- SCMA-5 is more compatible with existing structures and can be conducted immediately adjacent to buildings with fewer geotechnical stability concerns as compared to remedial strategies that require excavation (e.g., SCMA-3 and SCMA-4).

- SCMA-5 would be less energy intensive than other active remedies (e.g., SCMA-6) and would not generate large volumes of landfill waste as would be generated with SCMA-3.

- SCMA-5 would be easier to implement than SCMA-3, SCMA-4, and SCMA-6, which would both require air permitting and discharge of treated vapors to the atmosphere, as well as likely treatment and discharge of liquid condensate.

6.2 SCMA-5 Treatability Evaluation and Design

In support of the feasibility evaluation for SCMA-5, geotechnical information and soil samples were collected in June 2014 as part of the pre-design investigation and treatability sample collection program. The purpose of this investigation was to provide data for a preliminary assessment of the viability of the ISSS technology at the Site. Two geotechnical soil borings (SPT-A and SPT-B) were advanced in June 2014 within the two proposed remediation zones. Standard penetration tests (SPT – ASTM D1586) were conducted on these borings and soil samples were collected for Liquid Limit (ASTM D4318), plastic limit (ASTM D4318), and for preliminary ISSS treatability testing.

The preliminary ISSS testing involved mixing two batches of a soil sample from each remediation zone, one with a 5% Portland Cement content by dry weight and one with a 20% content by dry weight. These mix percentages represent the expected lower and upper limits of mix ratios typically used for ISSS. Densities and moisture contents were measured in the mixed samples and calculations presented in Table C-2 (**Appendix C**) were used to estimate an expected bulking factor which was used to calculate the total volume of treated soil after completion of the ISSS remedy. Based on the results of the calculations, an average bulking factor of 0.2 was estimated for the Site material across the range of expected mix ratios and expected in-situ densities. This estimated bulking factor of 0.2 indicates the final volume of treated soil would be approximately 20% greater than the initial volume. The bulking factor of 0.2 corresponds with an additional 620 CY of material that would need to be graded into the existing surface or transported off-Site for landfill disposal.

It is expected that the majority of the additional soil volume generated with ISSS can be accommodated within the remediation zones by increasing the elevation of the existing surface grade. Remediation Zone A on the Koury Property would be repaved with concrete. Some limited elevation gain in this area may be required and an agreement on the exact design of the final surface elevation would be finalized during the design phase. Any material not incorporated into the final surface grade would be removed from the Site for appropriate disposal at a landfill. Remediation Zone B on the Johnston Property is undeveloped and an increase in surface grade in this area is not expected to impact operations at the facility. It is therefore expected that all treated soils in Remediation Zone B would be retained at the Site, and would be graded and vegetated to promote surface water runoff.

The two sample mixes from each remediation zone were allowed to cure for 17 days and were tested with a pocket penetrometer to evaluate strength of the treated soil on days 6, 7, and 17 after sample preparation. Higher strength of the material is correlated with lower permeability and therefore this measurement was used as a general indication of treatment effectiveness in the preliminary testing. In general, a compressive strength of at least 3.6 tons per square foot (TSF) or 50 pounds per square inch (PSI) indicates that the mix would be effective at limiting COPC migration. Results of the tests are summarized on Table C-3 (**Appendix C**) and indicate that the 5% Portland Cement mix in Remediation Zone A was adequate to effectively treat the sample, but that the strength of the 5% Portland Cement mix in Remediation Zone B was not adequate. Lower strength in sample B at 5% Portland Cement could likely be due to higher than necessary moisture levels in this sample (see Table C-2 in **Appendix C**). Further testing during the design phase would be used to optimize moisture levels which possibly could achieve the desired strength in Remediation Zone B with a 5% Portland Cement mix. Otherwise Portland Cement fraction could be increased to 10% or above if need to achieve the desired strength (20% mix was demonstrated to have greater than necessary strength). Based on results of the testing, a Portland Cement mixture of 10% appears to be more than adequate to achieve the remedial goals and was therefore this mix ratio was used in the conceptual design and cost estimate (**Appendix D**).

Other geotechnical samples including liquid limit, plasticity limit and the SPT were used to evaluate the overall workability of the soil in regards to mixing for the ISSS treatment. Results of the liquid limit and plastic limit testing indicates the soil in both Remediation Zones is a fine sandy silt and both are below the plastic limits of clays that, if present, could potentially inhibit adequate mixing and /or excessive bulking of the treatment mixture (see Figures C-2 and C-3 in **Appendix C**). SPT blow counts per 6 inch boring advancement depth ranged from 0 to 7 within the treatment zone of 0 to 10 ft bls (see Figures C-4 and C-5 in **Appendix C**). These values are within the <10 blows per 6 inch depth values above which high soil density and strength begins to hamper implementation of an ISSS treatment. Results of the various geotechnical and treatability testing indicates that the ISSS technology appears to be a viable treatment method at the Site for encapsulating COPCs within a low-permeability monolith.

Additional testing would be required during the design phase of an ISSS remedy to refine the exact mix composition and implementation technique. The addition of other materials (e.g., activated carbon) to the treatment mix will also be considered and bench-scale tested during the design phase to enhance the COPC binding capacity of the ISSS monolith. Additionally, structural assessment of buildings and footers as well as additional geotechnical evaluation of soil could be performed by the remediation contractor during the design phase to assess the engineering controls that would be required to ensure that the building walls would not be damaged during implementation of the ISSS remedy.

6.3 Selected Groundwater Corrective Measure

GCMA-3 (MNA and ICs) is recommended as the preferred groundwater remedy for the Site. GCMA-3 includes ICs to control risks to human health and the environment, ongoing natural processes to reduce COPC concentrations, and long-term monitoring of groundwater to evaluate and document these decreases over time. Monitoring COPC concentrations would be performed over a 30-year period, or until COPCs have achieved MCSs for groundwater. Effectiveness of the remedy would be evaluated every 5 years after remedial implementation.

Advantages of GCMA-3 and reasons for selection of GCMA-3 as the preferred remedy include the following:

- GCMA-3 performs well when evaluated against each of the nine screening criteria and would achieve MCSs approximately over the same timeframe as the more aggressive GCMA-4.

- GCMA-3 monitors and documents attenuation of COPCs in groundwater and would confirm effectiveness of the selected soil remedy.

- There are no unacceptable risks to human health or the environment from the COPCs within groundwater at the Site.

- GCMA-3 is much easier to implement, has fewer short-term risks, and is much more cost-effective than GCMA-4 (total estimated cost of $620,000 for GCMA-3 vs. $5,800,00 for GCMA-4).

Implementation of GCMA-3 includes an initial sampling and analysis plan (**Table 5-5)** including proposed monitor wells locations (**Figure 5-5**), which includes the following activities:

- Periodic groundwater elevation gauging in a focused list of Site and off-Site monitor wells in the existing well network to determine hydraulic gradients and approximate groundwater flow directions.

- Periodic collection of groundwater samples from 20 selected wells (MW-3, MW-6R, MW-7S, MW-7M, MW-7D, MW-7BR, MW-11, MW-12, MW-12D, MW-16, MW-17D, MW-19, MW-20, MW-22, MW-22BR, MW-27S, MW-27D, MW-29S, MW-29D, and MW-30) for laboratory analysis of VOCs by USEPA test method 8260B and field parameter readings of temperature, dissolved oxygen, conductivity, oxidation-reduction potential (ORP), and pH, and five wells (MW-6R, MW-7S, MW-19, MW-20, and MW-27S) would be selected for SVOC analysis by USEPA test method 8270C during each monitoring period. Specific wells selected for SVOC analysis are listed below.

- Surface water samples would be collected semi-annually from sample locations SW-3, SW-4, SW-5, and SW-6 in the Unnamed Creek for laboratory analysis of VOCs by USEPA test method 8260B. Locations of surface water samples included in the sampling plan are depicted on **Figure 5-5**.

- Groundwater sampling events would be conducted annually and surface water sampling would be conducted semi-annually starting in 2015. At any point in the future monitoring program, if a clear decreasing COPC concentration trend is observed in the majority of the Site monitoring wells and no increasing tends are observed in any of the wells, Ashland may request from NCDENR that the Site be transitioned to biennial (once every 2 years) sampling. Based on continued improvements in groundwater and or surface water, Ashland may subsequently request further decreases in sampling frequency or a reduction in the monitoring well network or a reduction in the number of surface water sample locations.

- A monitoring report would be prepared for submittal to NCDENR HWS annually after each sampling event. Monitoring reports will include tabulated groundwater and surface water data, comparisons to MCSs, historical data tables, and figures showing the Site and monitoring well layout.

6.4 Public Involvement

As is customary prior to Agency approval of a CMS Report, NCDENR will organize a 30-day public comment period with a meeting to discuss the proposed corrective measures. Changes to the proposed corrective measures may be considered after the public comment period. Otherwise, the CMS would become part of the public record and regulatory notification process. Notification processes for the proposed ICs would then be implemented.

6.5 Project Authority and Organization

Project personnel, including regulatory contacts and subcontractors are listed below:

Facility Owner/Occupant: Koury Corp.
Site Contact: Richard Vanore
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Additional Site Owner: Johnston Properties
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6.6 Schedule for Corrective Measures Implementation

An implementation schedule for the proposed corrective measures is included as **Figure 6-1**.

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Tables

Table 4-1. Media-Specific Cleanup Standards
Ashland Inc., Greensboro, North Carolina

Constituent	Soil MCSs [1] (mg/kg)	Groundwater MCSs [2] (µg/L)
Acetone	NE[3]	6,000
Benzene	NE[3]	1
2-Butanone	NE[3]	4,000
Carbon Tetrachloride	3	0.3
Chloroform	NE[3]	70
1,2-DCB	NE[3]	20
1,1-DCA	NE[3]	6
1,2-DCA	NE[3]	0.4
1,1-DCE	NE[3]	7
cis-1,2-DCE	NE[3]	70
Ethyl Benzene	27	600
Methyene Chloride	NE[3]	5
PCE	82	0.7
Toluene	820	600
TCE	NE[3]	3
1,1,1-TCA	640	200
VC	NE[3]	0.03
Xylenes	260	500

Notes:

MCSs	Media-Specific Cleanup Standards
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
NE	Not Established
NA	Not Applicable
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
cis-1,2-DCE	cis-1,2-dichloroethene
PCE	tetrachloroethene
TCE	trichloroethene
VC	vinyl chloride
1	Soil MCSs were based on NCDENR Preliminary Soil Remediation Goals (PSRG) - January 2014
2	NCAC 2L Groundwater Standards are used as MCSs for groundwater
3	Soil MCS was not established because constituent is not a Soil COPC

TABLE 5-1
SCREENING OF REMEDIAL TECHNOLOGIES TO ADDRESS SOIL
Former Ashland Facility
Greensboro, North Carolina

General Response Action	Remedial Technology	Remedial Technology Process Option	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation?
No Additional Action	No Additional Action	No Additional Action	No additional remedial actions would be performed.	Not effective at mitigating potential risk to Site workers or reducing constituents of potential concern (COPC) migration to groundwater.	Yes	No Cost	Yes, as baseline for comparison
Institutional Controls	Institutional Controls	Land Use Restrictions	Using legal actions to control land use. This typically involves a deed restrictive covenant and/or a Land Use Control Plan. A current environmental covenant was established on the former Ashland Property (2802 Patterson St.) in 2003 and will be maintained indefinitely while soil impacts are present on Site. Additional institutional controls would need to be established at the property located at 2800 Patterson St.	Land use restrictions are effective to protect human health and the environment by removing a risk pathway, however they do not effect mobility, toxicity, or volume of the COPCs. Deed restriction of land overlying the source areas to industrial use would eliminate the future potential risk pathway for site workers.	Already implemented at the former Ashland Property. The deed has been modified to only allow for industrial land use and restrictions on subsurface development for the period prior to attainment of corrective measures objectives. Could be easily implemented at the 2800 Patterson property pending owner approval.	Low	Yes
Containment	Physical Barriers	Low Permeability Cover	Using a low permeability cover to prevent infiltration of precipitation through the contaminated soil and to prevent risk from direct contact of soils.	Already present on the former Ashland Property. Not sufficiently effective at preventing migration of COPCs from soil to groundwater. Effectiveness is dependend on integrity and maintenance of the cap. Is not effective at reducing COPC toxicity or volume.	Currently implemented at the former Ashland Property and could be easily implemented at the 2800 Patterson Property pending owner approval.	Low to Moderate	No.
Removal	Excavation	Excavation	Involves the physical removal of impacted soils. Clean imported soils or treated soils from the excavation would be backfilled in the excavation pit.	Very effective at removing COPC mass from source areas. Excavation is a reliable technology that is effective for all constituents.	Implementable but highly disruptive to the Site operator. Excavation adjacent to the buildings is more difficult to implement and would require sheet piling or specialized excavation techniques. Excavation may not be able to remove all impacted soil directly adjacent or below the buildings.	Moderate	Yes
Disposal	Off-Site Disposal	Off-Site Disposal at Landfill	Excavated soils would be trucked off-Site for disposal at an appropriate landfill. Characteristic hazardous soil would need to be transported a long distance to a Subtitle C Hazardous Landfill.	Effective method for disposal of excavated soils. Requires periodic sampling and analysis of excavated soils. A high percentage of soil classified as characteristic hazardous would greatly increase remediation costs.	Implementable would not significantly disrupt current Site operations.	Moderate to High	Yes. Maintained in conjunction with excavation.
	Treatment and On-Site Disposal	On-Site Treatment and Backfill into Excavation	Excavated soils would be treated on-Site to remove COPCs and then backfilled. Generally, on-site ex-situ treatment methods involve thermal treatment.	Effective method in conjunction with excavation. Would effectively remove COPCs from soils, thereby limiting potential exposure pathways and migration of COPCS from soil to groundwater.	Implementable, but more difficult than off-site disposal due to the additional time and space needed to treat excavated soils prior to backfilling. Obtaining the appropriate treatment and air discharge permits may be difficult.	Moderate	Yes. Maintained in conjunction with excavation.
In-Situ Treatment	Physical	Stabilization/ Solidification	Stabilizing agents are mixed with soil *in-situ* to permanently reduce mobility of COPCs.	Stabilization/Solidification is an effective technology to reduce migration of COPCs from soil to groundwater and to reduce the potential exposure pathway to Site workers.	Implementable but solidificaiton adjacent to the buildings would be more difficult to implement and would require sheet piling or specialized mixing techniques. Solidificaiton may not be able to treat all impacted soil directly adjacent or below the buildings.	Moderate	Yes
		Soil Vapor Extraction (SVE)	*In-situ* removal of VOCs through application of negative-pressure to wells screened in the unsaturated soil zone.	SVE is an effective technology for chlorinated volatile organic compounds (CVOCs), however the relatively low permeability of Site soils may limit the effectiveness of this remedy.	Implementable but not effective.	Moderate	No, would not likely be effective.
		Conventional Air Sparging	*In-situ* stripping of VOCs from soil using air injection wells. Combined with SVE for extraction of vapors.	Air Sparge/SVE is an effective technology for CVOCs, however the relatively low permeability of Site soils may limit the effectiveness of this remedy.		Moderate to High	No, would not likely be effective.
		Steam/Hot Air Injection	Steam/hot air is forced into the subsurface via injection wells to strip VOCs from the subsurface. VOC vapors are collected using an SVE system.	Steam/Hot Air Injection is an effective technology for CVOCs, however the relatively low permeability of site soils may limit the effectiveness of this remedy.		High	No, would not likely be effective.

Footnotes on Page 2

TABLE 5-1
SCREENING OF REMEDIAL TECHNOLOGIES TO ADDRESS SOIL
Former Ashland Facility
Greensboro, North Carolina

General Response Action	Remedial Technology	Remedial Technology Process Option	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation?
In-Situ Treatment (Continued)	Thermal Desorption	Radio Frequency Heating	Electromagnetic energy is used to heat up aquifer materials and strip VOCs from the subsurface. VOC vapors are collected using an SVE system.	Not as effective as electrical resistivity heating or conductive heating	Implementable but less effective than other thermal technologies.	High	No, not as effective as other thermal technologies.
		Electrical Resistivity Heating	Conventional electricity is used to heat the subsurface and strip out VOCs. VOC vapors are collected using an SVE system.	*In-situ* thermal desorption of contaminants using electrical resistivity has been effectively applied at a variety of sites, however it is less effective in unsaturated zones.	Implementable but less-effective in unsaturated soil zones. Would likely require injection wells to hydrate the unsaturated soils.	High	No, Conductive heating is more suited to unsaturated soil zones
		Conductive Heating	Heating wells are installed in the subsurface and used to heat the subsurface and strip out VOCs. VOC vapors are collected using an SVE system.	*In-situ* thermal desorption of contaminants using thermal conduction has been effectively applied at a variety of sites. Likely more efective at the Site than electrical resistive heating.	Implementable.	High	Yes
	Chemical	Chemical Oxidation via Infiltration	Chemical oxidants (e.g., potassium permanganate, persulfate, Fenton's reagent, or hydrogen peroxide) are introduced to soil column via infiltration galleries.	*In-situ* chemical oxidation of contaminants via direct injection, mechanical mixing, and infiltration have been applied at a variety of sites and are effective for treatment of CVOCs. However, due to the presence of immobile free phase product (3-7%) contained within the pore space, in-situ chemical oxidation would not be appropriate for the Site. In-situ chemical oxidation could also potentially disrupt the naturally occurring attenuation processes occurring within Site soils and groundwater.	Implementable but not effective.	Moderate to High	No (not effective)
		Chemical Oxidation via Mechanical Mixing	Chemical oxidants (e.g., potassium permanganate, persulfide, Fenton's reagent, or hydrogen peroxide) are sprayed and mixed in-situ with an excavator.			Moderate to High	
		Chemical Oxidation via Direct Injection	Injection of chemical oxidants (e.g., potassium permanganate, persulfide, Fenton's reagent, or hydrogen peroxide) through injection wells or injection probes to degrade contaminants in-situ.	Primarily effective for saturated zone impacts, may be less effective for unsaturated zone impacts.		Moderate to High	
		Surfactant Flushing	Surfactants (or co-solvents) are injected to enhance dissolution and/or mobilization of residual and adsorbed phase contaminants. Combined with groundwater extraction to remove dissolved constituents.			High	
	Biological	Monitored Natural Attenuation	Monitored natural attenuation (MNA) is the reliance on active/naturally occurring contaminant degradation and attenuation. This is coupled with groundwater monitoring to document decreasing migration of COPCs from soil to groundwater.	Not effective in the short-term at reducing the toxicity, mobility, and volume of COPCs due to the high concentrations of COPCs and the presence of immobile free product contained within the source areas. MNA would be effective over a very long timeframe.	Implementable but not effective in the short-term.	Low	No
		Anaerobic Bioremediation	Injection of a degradable organic carbon source to stimulate enhanced reductive dechlorination by native microorganisms.	In-situ enhanced reductive dechlorination not effective for unsaturated soils.	Implementable but not effective.	High	No
		Aerobic Bioremediation	The injection of an oxygen source to stimulate aerobic degradation of organic contaminants	Not Effective - Site constituents are not readily degradable by aerobic bioremediation.	Implementable but not effective.	High	No
		Phytoremediation	Use of natural plant processes and microorganisms associated with the root system to remove, sequester, or degrade contaminants.	Not likely to have a significant effect on COPC concentrations in unsaturated soil.	Not Implementable - Would interfere with Site activities	Low	No

Footnotes:

BTEX- Benzene, Toluene, Ethylbenzene, and Xylenes
COPCs- Constituents of Potential Concern
CVOCs- Chlorinated volatile organic compounds
RCRA- Resource Conservation and Recovery Act
MNA- Monitored Natural Attenuation
SVE- Soil Vapor Extraction
USEPA- United States Environmental Protection Agency
VOC- Volatile organic compound
IDW- Investigation derived waste

TABLE 5-2
SCREENING OF REMEDIAL TECHNOLOGIES TO ADDRESS GROUNDWATER
Former Ashland Facility
Greensboro, North Carolina

General Response Action	Remedial Technology	Remedial Technology Process Option	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation?
No Action	No Additional Action	No Additional Action	No additional remedial actions or monitoring would be performed.	Not effective at reducing contaminants of potential concern (COPC) concentrations in groundwater or monitoring the extent and attenuation of COPCs.	Yes	No cost	Yes, as baseline
Institutional Controls	Access Restrictions	Groundwater Use Restrictions	Using legal actions to prevent groundwater use, control land use, and prohibit the installation of water supply wells. This typically involves a deed restrictive covenant and/or a Land Use Control Plan. Land use restrictions are currently established on the former Ashland Site, however similar restrictions would need to be implemented at the 2800 Patterson St. property and potentially in downgradient areas.	Groundwater use and land use restrictions are effective to protect human health and the environment. Use restrictions do not effect mobility, toxicity, or volume but serve to remove a potential risk pathway. Groundwater in the vicinity of the Site is not extracted for drinking or any other use. Restricting future use of groundwater for irrigation or recreational purposes would be protective of human health. An existing City ordinance restricts the installation of wells for water supply in teh vicinity of the Site.	Would require modification of deed to prohibit groundwater use or compel specific land use for the period prior to attainment of corrective measures objectives. Implementaion would require approval by property owners.	Low	Yes
		Land Use Restrictions					
	Water Supply Protection	Alternate Water Source	All properties within vicinity of the Site and groundwater plume are supplied by city water. No known water supply wells are present within this area.	Water supply protection measures are not needed.	Not applicable	Not applicable	No
		Point of Use Treatment					
Containment	Physical Barriers	Grout Injection	Pressure injection of grout through tightly spaced boreholes. Provides low permeability barrier (vertical or horizontal) to block contaminant migration.	Physical barriers are effective to prevent water from moving to off-site thereby providing protection to human health and the environment. However, the plume is mature and very deep within bedrock at this Site. Phyical barriers could not be reasonably installed at this SIte to prevent further migration.	Difficult to implement due to the depth of the plume.	High	No
		Slurry Wall	Using a bentonite slurry or other low permeability material placed in a trench to create a wall that prevents horizontal migration of contaminated water.				
		Sheet Piling	Using sheet piles to form a low permeability wall that prevents the horizontal migration of contaminated groundwater.				
Collection	Hydraulic Barriers	Extraction Wells	Extraction of site groundwater from vertical wells. Creates a local depression in the groundwater table which limits groundwater migration off the site. Extraction wells are a conventional mass removal and hydraulic barrier technique.	Groundwater extraction would do little to remediate the groundwater impacts as the total COPC mass removal would likely be very small compared to natural attenuation mechanisms. Extraction wells could potentially reduce COPC migration to the Unnamed Stream, but may also increase migration of off-Site COPCs toward the extraction wells which could result in some comingling of plumes or spreading of impacted groundwater areas.	Would be difficult to implement in the areas downgradient of the former Ashland Property due to the presence of commercial properties and buildings between the Property and the Unnamed Stream.	High	Yes
		Interceptor Trenches	Extraction of groundwater from collection trenches designed to maximize groundwater collection, particularly in low permeability formations.	Could be used to extract shallow groundwater in conjunction with extraction wells to collect deeper groundwater; however, the majority of the COPC mass transport appears to be in the partially weathered bedrock zone which would be too deep to address with trenches. Therefore receptor tranches would not significantly increase effectiveness beyond installation of only recovery wells.	Very difficult to implement in downgradient areas due to the presence of roads and commercial buildings in the area.	High	No. Poor effectiveness, difficult to implement.

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TABLE 5-2
SCREENING OF REMEDIAL TECHNOLOGIES TO ADDRESS GROUNDWATER
Former Ashland Facility
Greensboro, North Carolina

General Response Action	Remedial Technology	Remedial Technology Process Option	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation?
Ex-Situ Treatment	Physical	Air Stripping	Treatment of recovered groundwater by transferring contaminants from the aqueous phase to the vapor phase. Off-gas may require additional treatment.	Air stripping would be an effective technology to treat most COPCs. Air stripping would reduce the toxicity, mobility, and volume of COPCs in the extracted groundwater.	Implementable and commonly used in conjunction with groundwater extraction.	Moderate	Retained in conjunction with groundwater extraction.
		Carbon Adsorption	Contaminants are removed from the aqueous phase or vapor phase via adsorption onto activated carbon.	Carbon Adsorption would be an effective technology to treat the majority of the COPCs in extracted groundwater. Treatment would achieve reduction in toxicity, mobility, and volume of COPCs in the extracted groundwater.	Implementable and commonly used in conjunction with groundwater extraction.	Moderate	Retained in conjunction with groundwater extraction.
		Ion-Exchange	Use of an engineered resin or media to preferentially sorb ionic species from an aqueous stream.	Ion-exchange would be ineffective for treatment; chlorinated compounds are incompatible with this technology.	Implementable but ineffective	High	No. Not Effective.
		Membrane Technologies	This group of physical removal technologies relies on semi-permeable membranes to remove undesired contaminants from water. This process produces a concentrated liquid waste stream.	Membrane technologies are not recommended for treatment of chlorinated volatile organic compounds (CVOCs); therefore this technology is not considered effective.	Implementable but ineffective	High	No. Not as effective as other less expensive technologies.
	Chemical	Chemical Oxidation	Involves destruction of CVOCs by generating free radicals, primarily hydroxyl radicals, an oxidizing agent that can destroy most organic pollutants in water. The most common technique in this group of technologies is ultra-violet (UV) oxidation, which involves UV photolysis of hydrogen peroxide.	Advanced Oxidation is a suitable technology for COPCs and would be effective in reducing toxicity, mobility, and volume of COPCs in extracted groundwater. The potential presence of particulates and metals in extracted groundwater may inhibit effectiveness. ISCO treatment may also result in higher dissolved metal cocnentraitons in treatment effluent.	Implementable, but not as cost-effective or reliable as air stipping or carbon adsorption.	High	No. Not as effective as other less expensive technologies.
		Zero-Valent Iron	Use of reactive iron to chemically reduce volatile organic compounds (VOCs) or immobilize inorganics *ex-situ* .	Zero valent iron is a suitable technology for most COPCs and would be effective in reducing toxicity, mobility, and volume of COPCs in extracted groundwater.	Implementable, but more complex and less cost-effective than other proven technologies.	High	No. Not as effective as other less expensive technologies.
		Thermal Oxidation	Thermal oxidation of hydrocarbons in a heated vapor stream.	Effective to thermally treat most COPCs in extracted groundwater. Would typically be used in conjunction with other treatment technologies (e.g. air stripping).	Implementable, but more complex and less cost-effective than other proven technologies. Would likely require air-permitting.	High	No. More difficult and less cost-effective than other technologies.
		Catalytic Oxidation	Oxidation of hydrocarbons in a vapor stream using a catalyst to decrease the temperature required for oxidation to occur.	Effective for CVOCs. Would typically be used in conjunction with other treatment technologies (e.g. air stripping).	Implementable, but more complex and less cost-effective than other proven technologies.	Moderate	No. More difficult and less cost-effective than other technologies.
	Biological	Aerobic Bioreactor	Aerobic biodegradation performed in an engineered bioreactor for contaminant removal from a process stream.	Aerobic biodegradation is not effective for treatment of CVOCs.	Implementable but ineffective	Moderate to High	No. Not effective.
		Anaerobic Bioreactor	Biodegradation in the absence of oxygen performed in an engineered bioreactor for contaminant removal from a process stream.	Anaerobic biodegradation is an effective technology to treat CVOCs in conjunction with groundwater extraction; however, long retention times necessary for treatment would result in excessive reactor volumes and difficult, inconsistent treatment.	Not constructible at reasonable scale. Would likely result in operational problems and difficulty achieving corrective measures objectives.	High	No. Not as effective as other less expensive technologies.

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TABLE 5-2
SCREENING OF REMEDIAL TECHNOLOGIES TO ADDRESS GROUNDWATER
Former Ashland Facility
Greensboro, North Carolina

General Response Action	Remedial Technology	Remedial Technology Process Option	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation?
Disposal/Discharge	Discharge	Publicly-Owned Treatment Works (POTW)	Off-site discharge to a POTW under applicable discharge permits.	Discharge of groundwater associated with groundwater extraction at a POTW would be effective as a discharge technology.	Not implementable due to permitting issues with the City of Greensboro.	Moderate to High	No
		Beneficial Re-use	Non-potable on-site reuse of treated groundwater.	Not effective - no existing use for extracted water.	Implementable but not effective.	Moderate	No
		Groundwater Reinjection	Reinject treated groundwater meeting United States Environmental Protection Agency and North Carolina Department of Environment and Natural Resources discharge limits outside the areas of contamination.	Would not be effictive as it would provide little to no benefit at the Site.	Difficult to implement due to little available space among the commercial properties in the area.	Moderate to High	No
		Surface Water Discharge	Discharge treated groundwater meeting NPDES permit limits to the Unnamed Creek.	Effective method to discharge properly treated water. Would need to be monitored periodically and meet standards specified in the NPDES permit.	May be implementable pending approval by the City of Greensboro and NPDES permitting; however, a high level of treatment would be required to achieve NPDES discharge criteria.	Low	Yes
		Atmospheric Discharge	Discharge of vapor streams meeting allowable discharge limits to the atmosphere	Effective method to discharge VOC vapors from treated water. VOC discharge mass would be low due to the generally low level VOC impacts in downgradient areas.	Easily Implementable	Low	Yes
In-Situ Treatment	Physical	Aquifer Sparging/Soil Vapor Extraction	*In-situ* stripping of VOCs using air injection wells and recovery of the resulting vapors by soil vapor extraction	Limited effectiveness at reducing plume-wide concentrations, especially in deep aquifer zones. Will also aerate groundwater which would likely decrease natural rates of bio-attenuation. The low permeability of overburden and the fractured nature of bedrock would also impead the effectveness of this technology.	Difficult to implement in deeper zones.	High	No. Limited effectiveness and difficult to implement.
		In-Well Stripping	In-well stripping of VOCs in a dual-screened well that pulls groundwater in at one interval and recharges it in the other after treatment. Stripped vapors are recovered at the wellhead.	Previously implemented on-Site with limited effectiveness. Aerates groundwater which would likely decrease natural rates of bio-attenuation. The low permeability of overburden and the fractured nature of bedrock would also impead the effectveness of this technology.	Difficult to implement in deeper zones.	Moderate to High	No. Low effectiveness and difficult implementation.
		Thermal/Heating	Involves heating of the aquifer matrix by a variety of methods to strip VOCs from the subsurface. VOC vapors are collected using soil vapor extraction.	Thermal heating would be effective for COPCs; however it would not be applicable for a mature, disperse plume. Thermal heating is typically used for source treatment in localized areas.	Not practically implementable or cost-effective for a dissolved plume and would result in a more difficult remedy installation and operation. Has the potential to cause disruption to the area and require specialized permitting and control in the operation of the remedy due to the electrical generation of heat.	High	No. Low effectiveness, difficult implementation and high cost.
	Chemical	Ozone	Use of ozone and ozone generated radicals to oxidize organic contaminants in-situ by injecting into the subsurface through injection wells.	Oxidation by use of ozone has shown to be highly effective for aliphatic compounds and would serve to reduce the toxicity, mobility, and volume of COPCs the aquifer. Effectiveness also would be likely limited by the inability to adequately distribute the oxidant in-situ due to the low permeability of the shallow aquifer zone. Oxidation of the aquifer would likely counteract the existing reductive dechlorination natural attenuation processes present within the majority of the plume.	Difficult to implement due to ozone's high reactivity and instability. Hazardous materials storage and handling practices and precautions and strict Health and Safety requirements would be necessary for workers. The corrective measures implementation Health and Safety Plan would also require procedures for community near the Site during remedy implementation. The presence of buildings immediately downgradient of the source areas would significantly limit access to the most impacted portions of the groundwater plumes.	High	No. Low effectiveness, difficult implementation and high cost.
		Fenton's Reagent	Generation of hydroxyl radicals via catalyzed hydrogen peroxide reactions. The hydroxyl radicals subsequently oxidize organic contaminants. Reagents would be injected into the subsurface through injection wells.	Oxidation using liquid hydrogen peroxide in the presence of native or supplemental ferrous iron produces Fenton's Reagent which yields free hydroxyl radicals. These strong nonspecific oxidants are effective in degrading COPCs. Fenton's Reagent is most effective under acidic conditions (pH 2 to 4) and becomes ineffective in strongly alkaline conditions. Effectiveness also would be likely limited by the inability to adequately distribute the oxidant in-situ due to the low permeability of the shallow aquifer zone. Oxidation of the aquifer would likely counteract the existing reductive dechlorination natural attenuation processes present within the majority of the plume.	Difficult and dangerous to implement. Requires highly trained crew and management team and may require specialized permitting. Reactions are very rapid. There is the potential for handling large quantities of hazardous oxidizing chemicals due to the oxidant demand. This technology is deemed non-implementable due to the disperse and deep nature of the plume and the large number of chemical injections that would need to be performed among a populated commercial area. The presence of buildings immediately downgradient of the source areas would significantly limit access to the most impacted portions of the groundwater plumes.	High	No. Low effectiveness, difficult implementation and high cost.
		Persulfate	Generation of sulfate and other radicals through catalyzed dissociation of the persulfate molecule. The generated radicals subsequently oxidize organic contaminants. Reagents would be injected into the subsurface through injection wells.	Oxidation using persulfate would have limited effectiveness and would likely counteract the existing reductive dechlorination natural attenuation processes present within the majority of the plume. Effectiveness also would be likely limited by the inability to adequately distribute the oxidant in-situ due to the low permeability of the shallow aquifer zone.	Implementable but not cost-effective for treating a large disperse plume. The presence of buildings immediately downgradient of the source areas would significantly limit access to the most impacted portions of the groundwater plumes.	High	No. Low effectiveness, difficult implementation and high cost.

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TABLE 5-2
SCREENING OF REMEDIAL TECHNOLOGIES TO ADDRESS GROUNDWATER
Former Ashland Facility
Greensboro, North Carolina

General Response Action	Remedial Technology	Remedial Technology Process Option	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation?
In-Situ Treatment	Chemical	Permanganate	Use of permanganate to oxidize contaminants in situ. Reagents would be injected into the subsurface through injection wells.	Permanganate chemical treatment via subsurface injection is suitable to treat COPCs however it is not ideal for treating a large, disperse plume. Oxidation of the aquifer would likely counteract the existing reductive dechlorination natural attenuation processes present within the majority of the plume. Effectiveness also would be likely limited by the inability to adequately distribute the oxidant in-situ due to the low permeability of the shallow aquifer zone.	Implementable but not cost-effective for treating a large, disperse plume.	High	No. Low effectiveness, difficult implementation and high cost.
	Abioitic	Zero Valent Iron	Use of Zero Valent Iron (ZVI) to abiotically reduce contaminants in-situ. ZVI can be implemented through installation of a reactive wall or can be driectly injected into the subsurface.	ZVI is effective to treat CVOCs in groundwater. Iron granules dissolve slowly providing long-term treatment; however, there is the possibility that reactive capacity may be lost requiring replacement of medium. Treatment may also decrease due to precipitation of metals salts. Biological activity (known to occur at the Site) or chemical precipitation may limit the permeability of the treatment wall. Effectiveness also would be likely limited by the inability to adequately distribute the ZVI in-situ due to the low permeability of the shallow aquifer zone.	Implementation of a reactive wall would not be implementable due to the depth of impacts at the Site. Injection would be implementable but difficult and costly due to the depth of impacts within the aquifer.	High	No. Low effectiveness, difficult implementation and high cost.
	Biological	Monitored Natural Attenuation (MNA)	MNA is the reliance on active/naturally occurring contaminant degradation and attenuation processes. This is coupled with groundwater monitoring to document remedial progress and to track the nature and extent of the groundwater plume.	Natural processes have been shown to be effective in reducing the COPC concentration at the Site. MNA would provide for reduction in toxicity, mobility, and volume over a long period of time, but would have little effect on COPC concentrations in the short term.	MNA is implementable as natural processes are on-going in the aquifer. Monitoring associated with MNA is implementable as the groundwater monitoring well system is already in place. Would be implemented with institutional controls and a selected soil remedy to mitigate further migration of COPCs from soil to groundwater.	Low	Yes
		Anaerobic Bioremediation	Injection of a degradable organic carbon source to stimulate enhanced reductive dechlorination by native microorganisms.	Enhanced reductive dechlorination (ERD) technology is highly effective for target COPCs. Degradation of COPCs is already taking place across the majority of the plume and this technology would increase the degradation rates. However, effectiveness would be likely limited by the inability to adequately distribute the carbon source in-situ due to the low permeability of the shallow aquifer zone. Low pH buffering capacity within the bedrock would also be an impedement to this technology within the bedrock zone.	Installation of injection wells off-Site would be difficult to implement and ERD would also cause Health and Safety concerns for downgradient buildings from methane production.	High	No. Difficult to implement in deep zones and potential safety concern for downgradient facilities.
		Aerobic Bioremediation	The injection of an oxygen source to stimulate aerobic degradation of organic contaminants	Chlorinated VOCs are the primary COPCs at the Site - this technology would likely counteract the reductive dechlorination processes presently occuring in the aquifer.	Implementable but not effective.	High	No. Not effective.
		Phytoremediation	Use of natural plant processes and microorganisms associated with the root system to remove, sequester, or degrade contaminants.	Technology would treat COPCs in shallow aquifer zones, but is likely already occuring to a small degree in downgradient areas near the Unnamed Creek. The majority of COPCs present within deeper zones would not be affected by this technology.	Not implementable due to density of existing commercial facilities in downgradient portions of the plume.	Low	No. Not implementable.

Footnotes:

BTEX- Benzene, Toluene, Ethylbenzene, and Xylenes
COPCs- Constituents of Potential Concern
CVOCs- Chlorinated volatile organic compounds
MDEQ- Mississippi Department of Environmental Quality
mm Hg- Millimeters of mercury
NPDES- National Pollution and Discharge Elimination System
POTW- Publicly-Owned Treatment Works
RCRA- Resource Conservation and Recovery Act
SVE- Soil Vapor Extraction
USEPA- United States Environmental Protection Agency
VOC- Volatile organic compound
IDW- Investigation derived waste

Table 5-3
Soil Corrective Measure Alternative Evaluation
Former Ashland Facility – Greensboro North Carolina

RCRA Corrective Action Screening Criterion / Alternative Number	Alternative SCMA-1	Alternative SCMA-2	Alternative SCMA-3	Alternative SCMA-4	Alternative SCMA-5	Alternative SCMA-6
Remedial Alternative	**No Additional Action**	**Institutional Controls (ICs)**	**Excavation with Off-Site Disposal, Backfill with Imported Soil and ICs**	**Excavation with On-Site Treatment, Backfill with Treated Soil and ICs**	***In-Situ* Soil Stabilization and ICs**	***In-Situ* Thermal Desorption and ICs**
Overall Protection of Human Health and the Environment	Risk associated with soil impacts at the Facility are currently managed through institutional and management controls. The "No Additional Action" alternative would not reduce or eliminate migration of Constituents of Potential Concern (COPCs) from soil to groundwater.	Institutional Controls (ICs) limiting use of the property and ensuring that the asphalt and concrete surface barriers remain in place, would be protective of human health and the environment by reducing potential exposure to Site workers and by reducing migration of residual COPCs in soil to groundwater.	Excavation with off-site disposal and backfill with imported soil is an effective long-term remedial alternative for the site. Excavation is protective of both human health and the environment as COPCs are removed from Site soils, reducing potential exposure to Site workers and migration of COPCs from soil to groundwater.	Excavation with on-Site treatment and backfill with treated soil is an effective long-term remedial alternative for the site. By removing COPCs from Site soils, excavation with on-Site treatment is protective of both human health and the environment. Excavation with on-Site treatment removes COPCs from Site soils thereby preventing exposure to Site workers and migration from soil to groundwater.	*In-situ* soil stabilization (ISSS) is an effective long-term remedial alternative for the site. Soil within the source areas would be mixed with binding agents (e.g., Portland cement or similar compound) to encapsulate COPCs within an impermeable monolith, thereby reducing potential exposure to Site workers and migration of COPCs from soil to groundwater.	*In-situ* thermal desorption (ISTD) is an effective long-term remedial alternative for the Site. Soil within source areas would be heated to volatilize COPCs and soil vapor extraction (SVE) wells would remove site COPCs thereby reducing potential exposure to Site workers and migration of COPCs from soil to groundwater.
Attain Media Cleanup Standards (MCS)	No Action does not directly achieve Media Cleanup Standards (MCSs) and does not ensure that ICs remain in place.	Volatilization and other natural processes would slowly reduce COPC concentrations over a long timeframe and ICs would be maintained over time to limit potential human exposure to COPCs.	Excavation with off-site disposal would achieve MSCs for soil within a short time frame.	Excavation with on-Site treatment and backfill with treated soil will effectively reduce COPC concentrations in Site soils; however, at a slightly longer time period as compared to off-site disposal.	ISSS would not remove COPCs from Site soils. However, it would form a very low permeability monolith which would significantly reduce migration of COPCs to groundwater and potential exposure to Site workers.	ISTD would achieve the MCSs within approximately 1 year.
Control of the Sources of Releases	The source areas are partially covered by existing asphalt pavement and the existing Resource Conservation Recovery Act pad reduces migration of the soil impacts to groundwater. The No Additional Action would not further aid in controlling the sources further nor would it confirm the current barriers remain in place.	The existing surface barriers at the Facility would limit potential human exposure and reduce migration of soil impacts to groundwater; however, surface barriers are not present at the Johnston Properties facility. ICs also would not directly decrease concentrations of COPCs in site soils.	The unsaturated soil source areas would be removed from the Site. The excavated source areas would be backfilled with imported clean soil. Therefore, the sources of releases would be controlled within the excavation areas.	The source areas would be removed from the Site. The excavated soils would be treated on-Site, and then used as backfill. Therefore, the sources of releases would be controlled within the excavation areas.	The source areas would be stabilized in-situ to effectively control the source of releases to groundwater.	ISTD would remove COPCs from the source areas, thus controlling the sources of releases.
Compliance with Standards for the Management of Wastes	No wastes would be generated; and thus no wastes would need to be managed.	No wastes would be generated; therefore, no wastes would need to be managed.	Excavated soils containing high concentrations of COPCs would be generated and must be managed in accordance with industry standards as they are transported off-site for disposal at an appropriate landfill.	Waste would be generated including spent granular activated carbon (GAC) that must be managed in accordance with industry standards. However, there would be no off-site disposal of excavated soils. Air permitting would also be required for the treatment system discharge to atmosphere.	Some amount of soil bulking would occur. If the Site cannot accommodate the additional volume of soil, then a relatively small amount of non-hazardous soil may need to be transported for off-site disposal. This potential waste would be handled in accordance with industry standards.	Volatilized COPCs would be treated on-Site, which would require air permitting and a pretreatment permit to allow discharges to the sanitary sewer system. The treatment system would likely include GAC treatment which would require off-Site disposal or regeneration. All wastes would be appropriately handled in accordance with industry standards.
Long-Term Reliability and Effectiveness	The No Additional Action alternative would not provide long term reliability or effectiveness. Natural volatilization and degradation of the source zone COPCs would provide limited reductions in source mass over time.	ICs would be moderately effective at providing long term protection as long as the ICs are maintained. Natural volatilization and degradation of the source zone COPCs and continued leaching to groundwater would provide limited reductions in source mass over time.	Excavation with off-site disposal and backfill with imported soil would provide long-term reliability and effectiveness indefinitely. The COPCs within the source zones would be permanently removed from the Site.	Excavation with on-Site treatment and backfill with treated soil would provide long-term reliability and effectiveness indefinitely. The COPCs within the treatment zones would be permanently removed from the Site.	ISSS would provide long-term reliability and effectiveness. The COPCs within the source zones would be effectively stabilized, preventing off-site migration over a long timeframe.	ISTD would provide long-term reliability and effectiveness indefinitely. The COPCs within the source zones would be effectively removed from the Site.

Table 5-3
Soil Corrective Measure Alternative Evaluation
Former Ashland Facility – Greensboro North Carolina

RCRA Corrective Action Screening Criterion (Continued)	**Alternative SCMA-1**	**Alternative SCMA-2**	**Alternative SCMA-3**	**Alternative SCMA-4**	**Alternative SCMA-5**	**Alternative SCMA-6**
	No Additional Action	**Institutional Controls (ICs)**	**Excavation with Off-Site Disposal and Backfill with Imported Soil**	**Excavation with On-Site Treatment and Backfill with Treated Soil**	***In-Situ* Soil Stabilization**	***In-Situ* Thermal Desorption**
Reduction of Toxicity, Mobility, or Volume of Waste	The No Additional Action would not reduce the toxicity, mobility, or volume of COPCs nor would it ensure that barriers remain in place to limit risk or prevent migration of COPCs from soil to groundwater. Natural volatilization and infiltration of the source zone COPCs would provide limited reductions in toxicity, mobility, and volume of COPCs over time.	ICs would not reduce the toxicity, mobility, or volume of COPCs but they would ensure that barriers remain in place to limit risk and prevent migration of COPCs from soil to groundwater. Natural volatilization of the source zone COPCs would provide limited reductions in toxicity, mobility, and volume of COPCs over time.	Excavation with off-site disposal and backfill with imported soil would remove high concentrations of COPCs from the source zones. Therefore, the toxicity, mobility, and volume of COPCs would be greatly reduced at the Site.	Excavation with on-site treatment and backfill with treated soil would remove high concentrations of COPCs from the source zones. Therefore, the toxicity, mobility, and volume of COPCs would be greatly reduced at the Site.	ISSS would not remove the volume or toxicity of the COPCs from the source zones. However, the COPCs would be stabilized within a low permeability monolith, decreasing exposure to Site migration to groundwater.	ISTD would remove high concentrations of COPCs from the source zones. Therefore, the toxicity, mobility, and volume of COPCs would be greatly reduced within the Site subsurface.
Short-Term Effectiveness	The No Additional Action alternative would not be effective in the short term to limit COPC migration to groundwater or to limit risks to potential Site workers.	ICs would be effective at protecting human health in the short term but would not limit COPC migration to groundwater. No additional short term risks would be associated with the ICs alternative.	Excavation with off-site disposal and backfill with imported soil would be very effective at removing COPC mass from source areas in the short term. However, this remedy also has moderate short-term risks to Site workers and risks off-Site associated with transportation of large quantities of impacted soil over long distances. However, Site and off-Site risks would be mitigated by implementing Site health and safety measures.	Excavation with on-site treatment and backfill with treated soil would be effective at removing COPC mass from source areas in the short term, but would require more time than excavation with off-Site disposal. This remedy has moderate short term risks for Site workers during excavation and treatment operations, especially considering the excavations would remain open while excavated soil is treated prior to replacement. However, Site risks would be mitigated by implementing Site health and safety measures.	ISSS would have high short-term effectiveness and would require approximately 2 months to achieve the remedial goals. Additionally, short-term risks would be generally small, confined to Site workers and would be mitigated by implementation of Site Health and Safety Measures.	ISTD would be very effective at removing COPC mass from source areas in the short term. Immediately following remediation, COPCs would be effectively removed from the source areas.
Implementability	Implementation would require no additional action or required infrastructure.	Implementation would require no additional infrastructure, but would require periodic review and/or maintenance of ICs. This alternative is easily implementable. ICs would also be considered for the Johnson Properties facility; however, this could be more difficult if the property owner does not agree with the implementation of ICs at their property.	Excavation and backfilling is highly implementable; however, portions of the excavation would be adjacent to buildings and would require additional evaluation, specialized excavation techniques, and/or shoring of the excavation to prevent damage to building foundations. Current Site operations would not be significantly impacted by this remedy.	Excavation with on-Site treatment and backfill would be the most difficult alternative to implement, as it would be disruptive to a larger area of the Site, would take a relatively longer timeframe than most options, and would require additional air permitting for the treatment system. Additionally, Site security and stormwater management in regard to contact with excavated soil would be significant issues to address during implementation of this remedy.	ISSS is a highly implementable technology, but would require some bench-scale testing to refine the design. ISSS can be implemented without disrupting a large portion of the Site and can be completed in a relatively short timeframe. COPC volatilization and stormwater runoff would need to be monitored and potentially mitigated during implementation of this remedy.	Implementation would require a moderate to high capital cost. As the site is not currently active, site operations would not be significantly impacted, but mitigation measures would likely be required to minimize potential damage to buildings, and subgrade structures and utilities. Provision of required electrical service to the Site may be difficult and vapor intrusion in to adjacent buildings would need to be monitored and potentially mitigated during implementation of this remedy.
Cost	There would be no cost to implement the No Additional Action alternative since no additional effort would be required.	Low relative costs. Estimated costs would be $46,000 as presented in Table B-1.	Moderate to high relative costs. Estimated costs would be $2.1 million (MM) as presented in Table B-1.	Moderate relative costs. Estimated costs would be $1.9 MM as presented in Table B-1.	Low to moderate relative costs. Estimated costs would be $930,000 as presented in Table B-1.	Moderate to high relative costs. Estimated costs would be $4.1 MM to as presented in Table B-1.
Recommendation	**REJECTED.** Would not confirm presence of institutional controls into the future and would not reduce risk to potential future Site workers.	**RETAINED.** ICs will be retained in conjunction with other alternatives.	**REJECTED** due to relatively high short-term risks, high cost, high fuel use for trucking soil and additional unnecessary loading of landfills.	**REJECTED** due to difficult implementability at a small and confined Site, relatively longer timeframe to implement, increased risks associated with open excavations during treatment, uncertainty over acquiring air permits for on-Site treatment and discharge to atmosphere.	**RETAINED** to limit potential exposure to Site workers and to reduce off-Site migration of COPCs. Long term monitoring of groundwater would confirm COPC decreases over time.	**REJECTED** due to very high relative costs, long remedial timeframe, potential risk to buildings, below grade structures and utilities, and potential difficulties acquiring an air permit for on-Site treatment and discharge to atmosphere.

Table 5-4
Groundwater Corrective Measure Alternative Evaluation
Former Ashland Facility – Greensboro, North Carolina

RCRA Corrective Action Screening Criterion / Alternative Number / Remedial Alternative	GCMA-1 No Additional Action	GCMA-2 Institutional Controls (ICs)	GCMA-3 Monitored Natural Attenuation (MNA) and ICs	GCMA-4 Groundwater Recovery, Treatment and Discharge to Surface Water and ICs
Overall Protection of Human Health and the Environment	There are currently no unacceptable risks to human health or the environment due to exposures to groundwater. Additional corrective actions are being considered; however, because Constituents of Potential Concern (COPCs) are present in on-site and off-site monitor wells above the North Carolina Administrative Code 2L Groundwater Quality Standards (2L Standards), which were developed to protect humans drinking impacted groundwater. Additional corrective measures that incorporate monitoring will be necessary to confirm that risks do not increase over time.	Institutional Controls (ICs) limiting use of the groundwater at the Site and downgradient areas would be protective of human health and the environment by reducing potential exposure to groundwater; however, monitoring would be required to document COPC attenuation in groundwater.	Monitored natural attenuation (MNA) with ICs provides adequate protection of human health and the environment based on the results of the 2013 Risk Assessment Report within the RCRA Facility Investigation (ARCADIS 2013c). Periodic monitoring would be required to confirm attenuation continues over time. ICs have been implemented and would be maintained to protect human health.	Groundwater recovery and treatment with discharge to surface water (GCMA-4) would provide adequate protection of human health and the environment similar to GCMA-3. Periodic monitoring would be required to confirm COPC attenuation continues over time. ICs have been implemented and would be maintained to protect human health.
Attain Media Cleanup Standards (MCSs)	The No Additional Action alternative would achieve the 2L Standards over a very long time period. However, no protections for human health and the environment would be implemented in the meantime, and reductions in COPC concentrations would not be monitored and documented over time.	ICs would reduce the potential for human exposures; and thus when combined with other strategies, would allow the 2L Standards to be achieved, while ensuring protection to human health and the environment over time. ICs would have to be combined with other alternatives to be effective.	MNA would achieve the media cleanup standards (MCSs) over a long time period and protections for human health and the environment would be implemented in the meantime. Long-term reductions in COPC concentration would be monitored and documented over time.	GCMA-4 would achieve the MCSs over a long time period and protections for human health and the environment would be implemented in the meantime. Long-term reductions in COPC concentration would be monitored and documented over time. Low permeability of soils within the shallow aquifer would lead to long restoration timeframes which are not likely to be significantly different from MNA.
Control of the Sources of Releases	The No Additional Action alternative for groundwater would not control the source of the release. The source of releases would be controlled by the selected Soil Corrective Measure Alternative.	The ICs for the groundwater remedy would only reduce exposure risks to COPCs remaining in groundwater. Source of releases would have to be controlled by the selected Soil Corrective Measure Alternative.	The MNA and ICs groundwater remedy would monitor and document reductions in groundwater COPC concentrations over time. Source of releases would be controlled by the selected Soil Corrective Measure Alternative.	Source of releases would be controlled by the selected Soil Corrective Measure Alternative. Groundwater recovery may help reduce some discharge of COPCs to surface water. However, continuing off-Site sources of COPCs (e.g., former Chem-Solv, NCDOT, Dow Chemical, various drycleaners) may be drawn toward the recovery wells due to altered groundwater surface contours. These off-Site sources of COPCs would also continue to be discharged to surface water regardless of any potential groundwater remedy implemented at the Site.
Compliance with Standards for the Management of Wastes	No waste would be generated by this alternative.	No waste would be generated by this alternative.	The only waste generated during monitoring activities is purge water from the monitoring wells. This water will be managed in accordance with industry standards.	Recovered groundwater would be treated in compliance with industry standards and would be discharged to the Unnamed Stream. This option would require National Pollution Discharge Elimination System (NPDES) permitting and periodic sampling to confirm permit conditions are met.
Long-Term Reliability and Effectiveness	The No Additional Action alternative does not have long-term reliability or effectiveness as the natural attenuation processes would not be monitored over time and there would be no protections for human health and the environment during this attenuation period.	ICs could be implemented for a very long period of time. They do not; however, have long-term reliability or effectiveness as a stand-alone remedy, but would be combined with other alternatives.	This technology has demonstrated long- term effectiveness. When implemented in conjunction with a source soil corrective measure, MNA would likely restore groundwater within a period of time comparable to most reasonably implemented active remedies. MNA allows for assessment of changes over time and provides an opportunity to implement a contingency remedy in the event that COPC discharge to the Unnamed Creek increases over time. MNA has been implemented at numerous RCRA sites and is considered to be an industry-accepted method for addressing dilute groundwater plumes.	Groundwater recovery would provide long-term effectiveness as long as the recovery system is maintained. Long term operation of the groundwater recovery system would be very costly and COPC removal effectiveness decreases significantly over time as concentrations attenuate. Restoration time frames would be long in this geologic setting and as such major capital replacement programs would have to be implemented over the life of the project.
Reduction of Toxicity, Mobility, or Volume of Waste	The No Additional Action alternative would reduce the toxicity and volume of waste over a very long time period through natural attenuation processes; however, these reductions would not be monitored and no protections for human health and the environment would be implemented.	ICs will not reduce the toxicity, mobility, or volume of waste, but would be an effective component of the remedy when combined with other alternatives.	MNA provides reductions in toxicity and volume of waste over a long time period and these reductions would be monitored and documented over time. There is evidence that reductive dechlorination of target constituents is proceeding within the groundwater and therefore when combined with a source treatment remedy, MNA would be an effective remedy for groundwater restoration.	Groundwater recovery would reduce mobility of COPCs from the Site by creating a partial barrier to groundwater flow to the Unnamed Stream; however, a groundwater recovery system may exacerbate mobility of off-Site COPCs which could be drawn across the natural hydraulic divide. Due to the deep nature of COPC impacts, a complete barrier to COPC migration likely would not be established by any reasonably-constructed recovery system.
Short-Term Effectiveness	The No Additional Action alternative would not introduce any short term risks but would also not create any short-term benefits.	ICs can be effective in the short term for protecting human health and the environment and would incur no additional short term risks to Site workers or the community.	MNA and ICs can be effective in the short term for protecting human health and the environment and would incur minimal additional short term risks to Site workers and the community.	Groundwater recovery would reduce mobility of Site COPCs in a localized area near the barrier within a short timeframe. Moderate additional short-term risks would be associated with well installations, system construction and system operation and maintenance.

Table 5-4
Groundwater Corrective Measure Alternative Evaluation
Former Ashland Facility – Greensboro, North Carolina

Implementability	Implementation would require no additional action or required infrastructure.	Easily implemented through initiating protective covenants. Obtaining ICs for the Johnson Property facility; however, could be more difficult if the property owner does not agree with the implementation of ICs at their property.	This technology is readily implementable because it involves groundwater monitoring through the use of an existing monitor well network. A current groundwater monitoring program is already in place but would be modified for long-term MNA implementation.	Groundwater recovery would be extremely difficult to implement. Downgradient property owners would need to agree to system construction on their properties, additional down-gradient parcels likely would need to be leased, additional recovery wells would need to be installed adjacent to businesses and residences, and the recovery wells would need to be installed in multiple and very deep aquifer zones. An NPDES permit would also need to be obtained.
Cost	No cost would be required to implement.	Low relative costs. Estimated costs would be $46,000 as presented in Table B-2.	Low to moderate relative costs. Estimated costs would be $620,000 over a 30-year period for annual sampling as presented in Table B-2.	Extremely high long term costs. Estimated costs would be $5,800,000 over a 30-year period as presented in Table B-2. Cost-benefit would be very low compared to MNA.
RECOMMENDATION	**REJECTED.** Would not confirm protection of human health and the Environment over time.	**REJECTED** as a stand-alone option**.** Would not monitor or document reductions in COPC concentrations over time.	**RETAINED** as a primary option in conjunction with soil treatment due to high effectiveness and low cost.	**REJECTED** due to difficulties in implementation, poor cost effectiveness, only marginal groundwater benefits, and the fact this remedy may draw off-site COPCs toward the Unnamed Stream.

Table 5-5. **GCMA-3 - Groundwater and Surface Water Sampling and Analysis Plan**

Former Ashland Facility, Greensboro, North Carolina

	VOCs (8260B)+1,2-DCB	SVOCs (8270C) + 1,4-dioxane
Well ID	Annual Sampling	
MW-3	x	
MW-6R	x	x
MW-7S	x	x
MW-7M	x	
MW-7D	x	x
MW-7BR	x	
MW-11	x	x
MW-12	x	
MW-12D	x	x
MW-16	x	
MW-17D	x	
MW-19	x	
MW-20	x	
MW-22	x	
MW-22BR	x	
MW-27S	x	
MW-27D	x	
MW-29S	x	
MW-29D	x	
MW-30	x	
Trip Blank	x	
Equip. Blank	x	
IDW	x	
Duplicate	x	
Surface Water Sample Location	Semi-Annual Sampling	
SW-3	x	
SW-4	x	
SW-5	x	
SW-6	x	
Trip Blank	x	
Duplicate	x	

Notes:

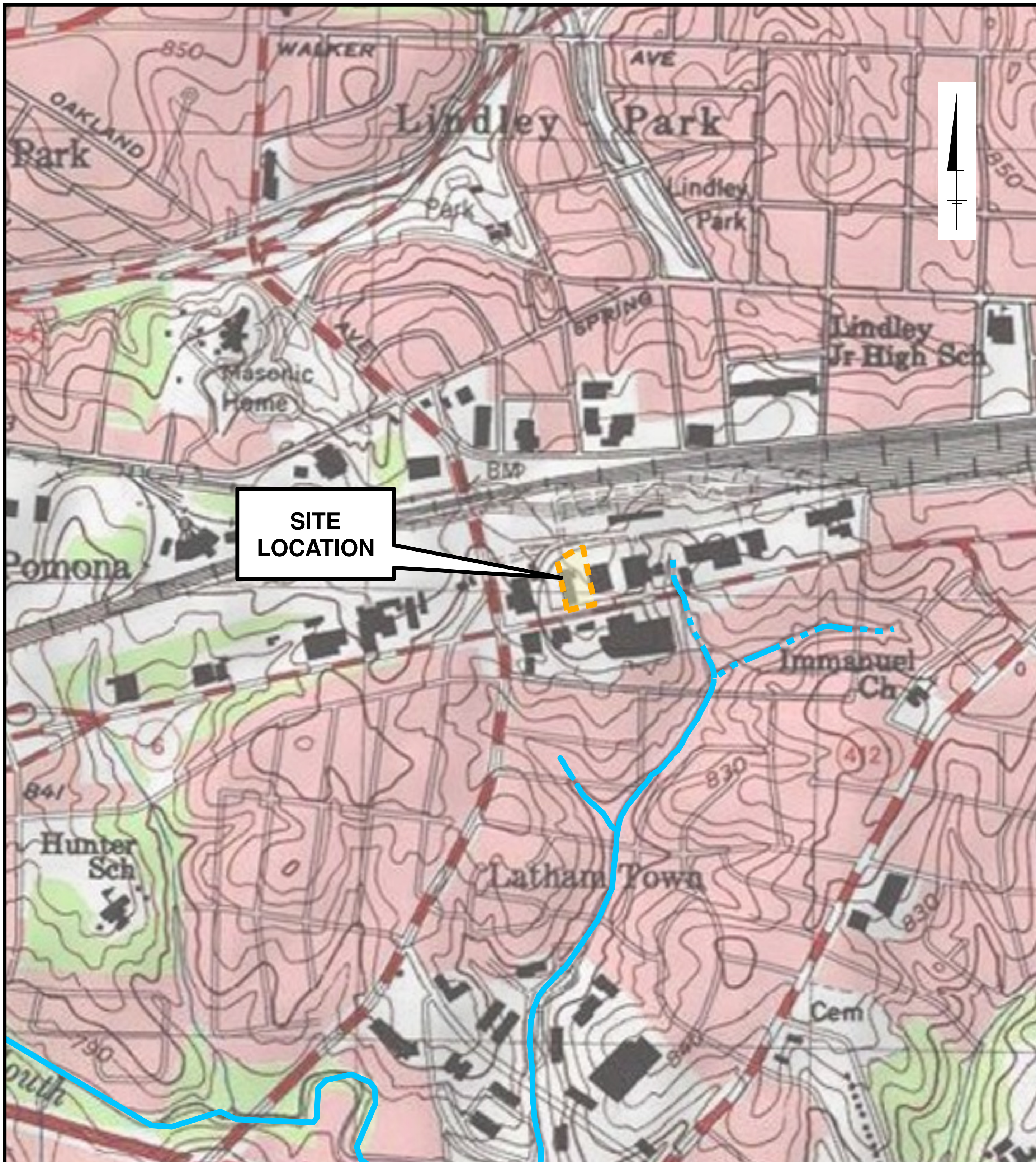
VOCs - Volatile Organic Compounds by USEPA Test Method 8260B

SVOCs - Semi-Volatile Organic Compounds by USEPA Test Method 8270C

1,2-DCB - 1,2-dichlorobenzene

x - Indicates analyses to be performed for listed sample.

Figures



0 500 1,000 2,000
Scale in Feet

County Location

Source: ArcGIS Online Services Hosted by ESRI.
USGS 7.5 Minute Greensboro, North Carolina Topographic Quadrangle.

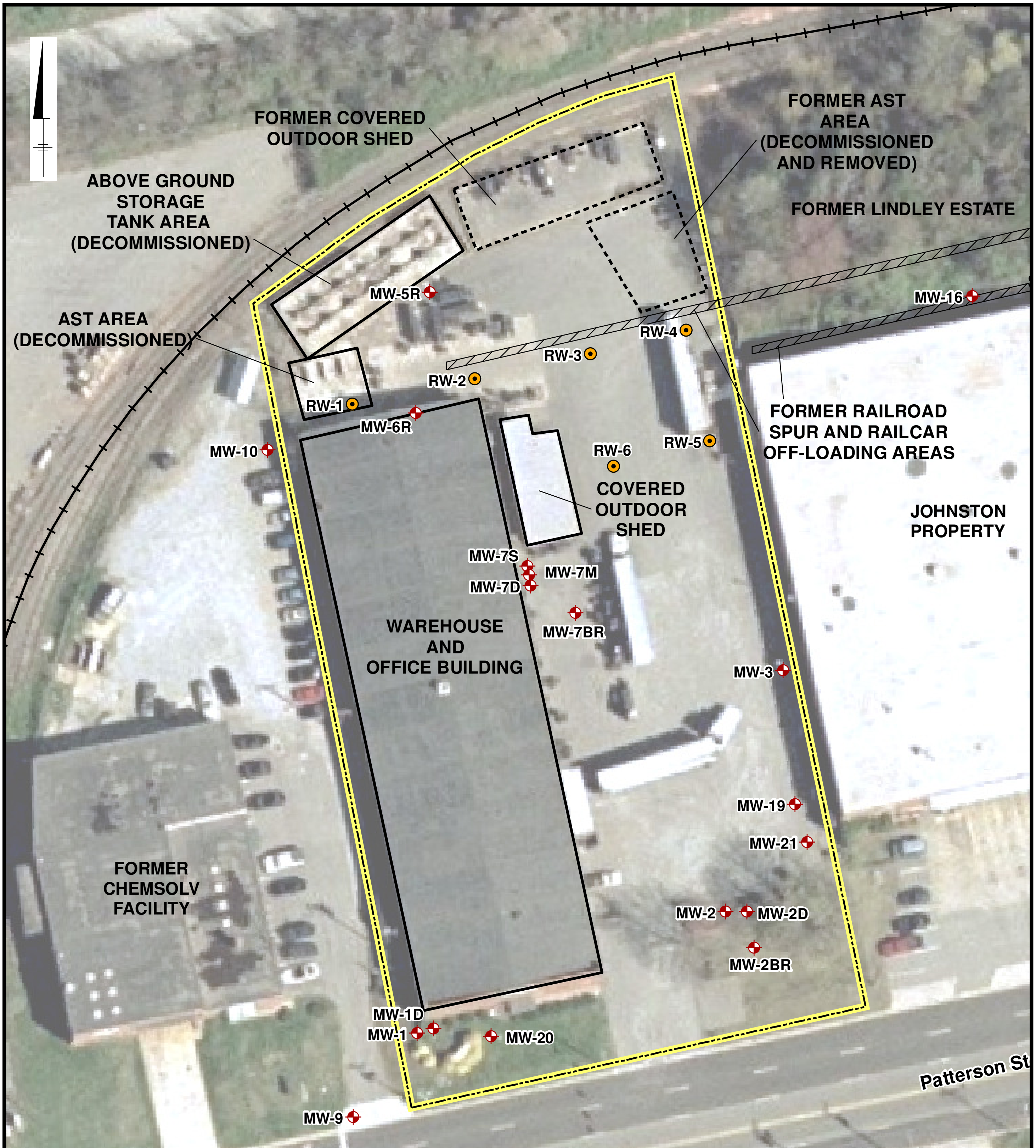
FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA
CORRECTIVE MEASURES STUDY

SITE LOCATION

ARCADIS

FIGURE
1-1

CITY: AUGUSTA DIV/GROUP: ENV DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
Project Number: Path: G:\ENVCAD\Augusta-GA\ACT\OH006000\NC06133303\RFI\2-1_OH06000B01.mxd Date Saved: 4/29/2013 8:48:14 AM



Legend
- Monitor Well
- ART Recovery Well
- Railroad Tracks
- Existing Area
- Former Area
- Former Spur
- Property

0 30 60 120

Scale in Feet

Image Source: ArcGIS Online Services Hosted by ESRI.

FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA

CORRECTIVE MEASURES STUDY

SITE LAYOUT

ARCADIS

FIGURE
1-2

CITY: AUGUSTA DIV/GROUP: ENV DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
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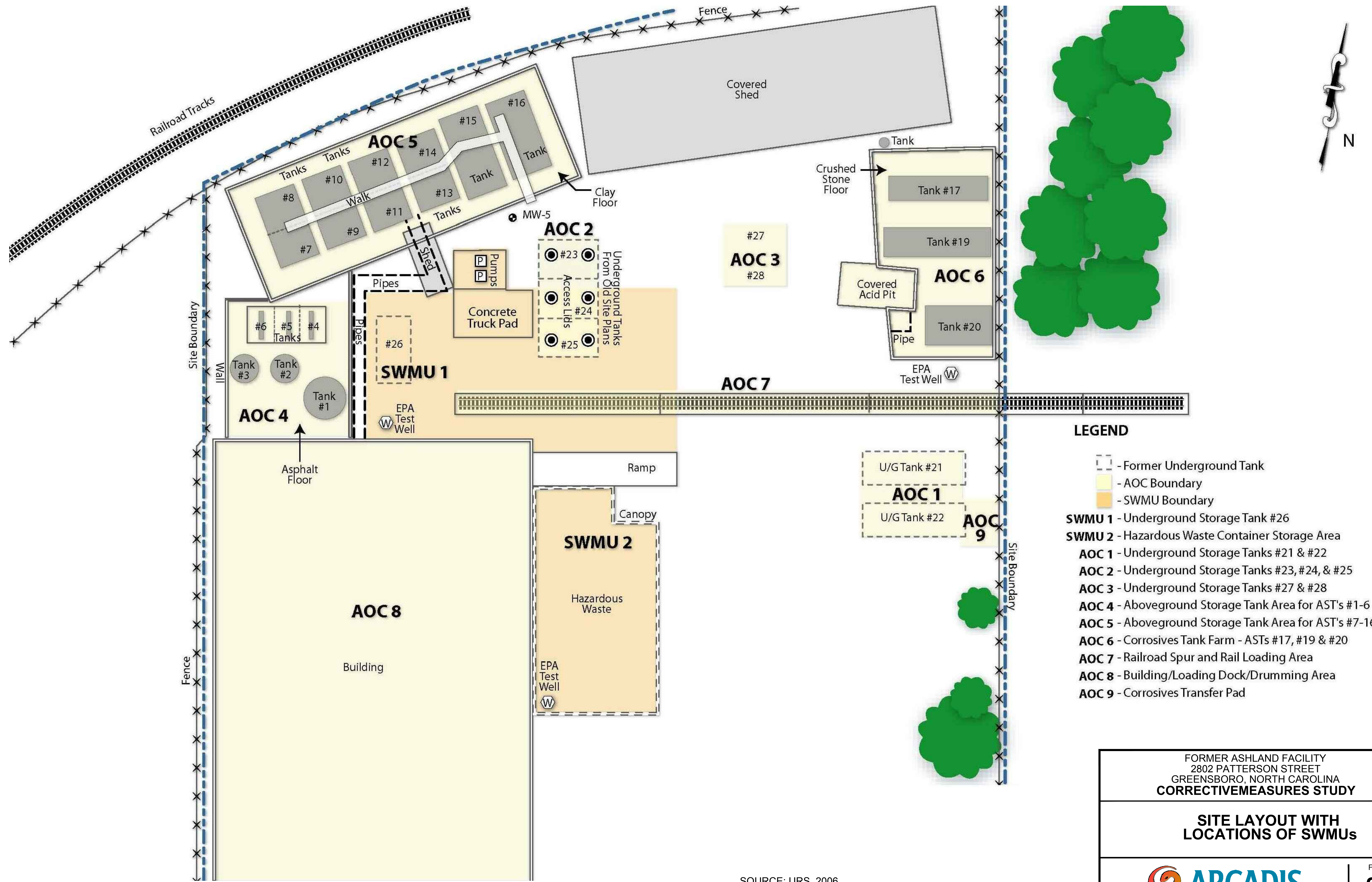
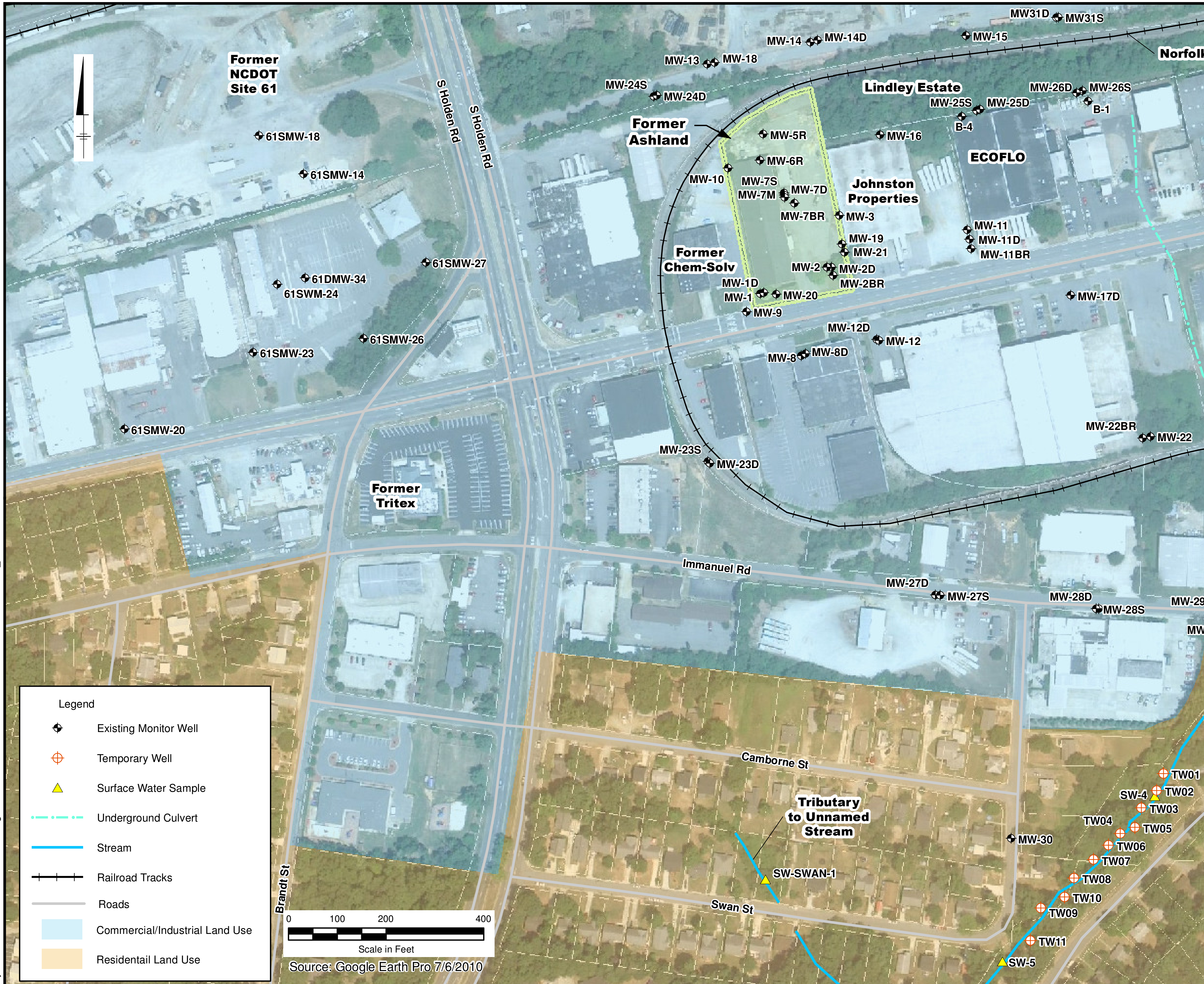


FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA
CORRECTIVEMEASURES STUDY

SITE LAYOUT WITH LOCATIONS OF SWMUs

ARCADIS

FIGURE
2-1



FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA

RCRA FACILITY INVESTIGATION

REGIONAL LAYOUT AND LAND USE

ARCADIS

FIGURE
2-2

FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA
CORRECTIVE MEASURES STUDY

OTHER POTENTIAL SOURCES WITHIN THE WATERSHED OF THE UNNAMED STREAM

ARCADIS

FIGURE
3-1

CITY: AUGUSTA DIV/GROUP: ENV DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
Project Number: Path: G:\ENVCAD\Augusta-GA\ACT\OH006000\NC06113303\RFI - Revised\2-4_OH6000B05.mxd Date Saved: 6/11/2013 3:05:21 PM

FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA
CORRECTIVE MEASURES STUDY

IDENTIFIED SOIL REMEDIATION ZONES

ARCADIS

FIGURE
3-2

CITY: AUGUSTA DIV/GROUP: ENV DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
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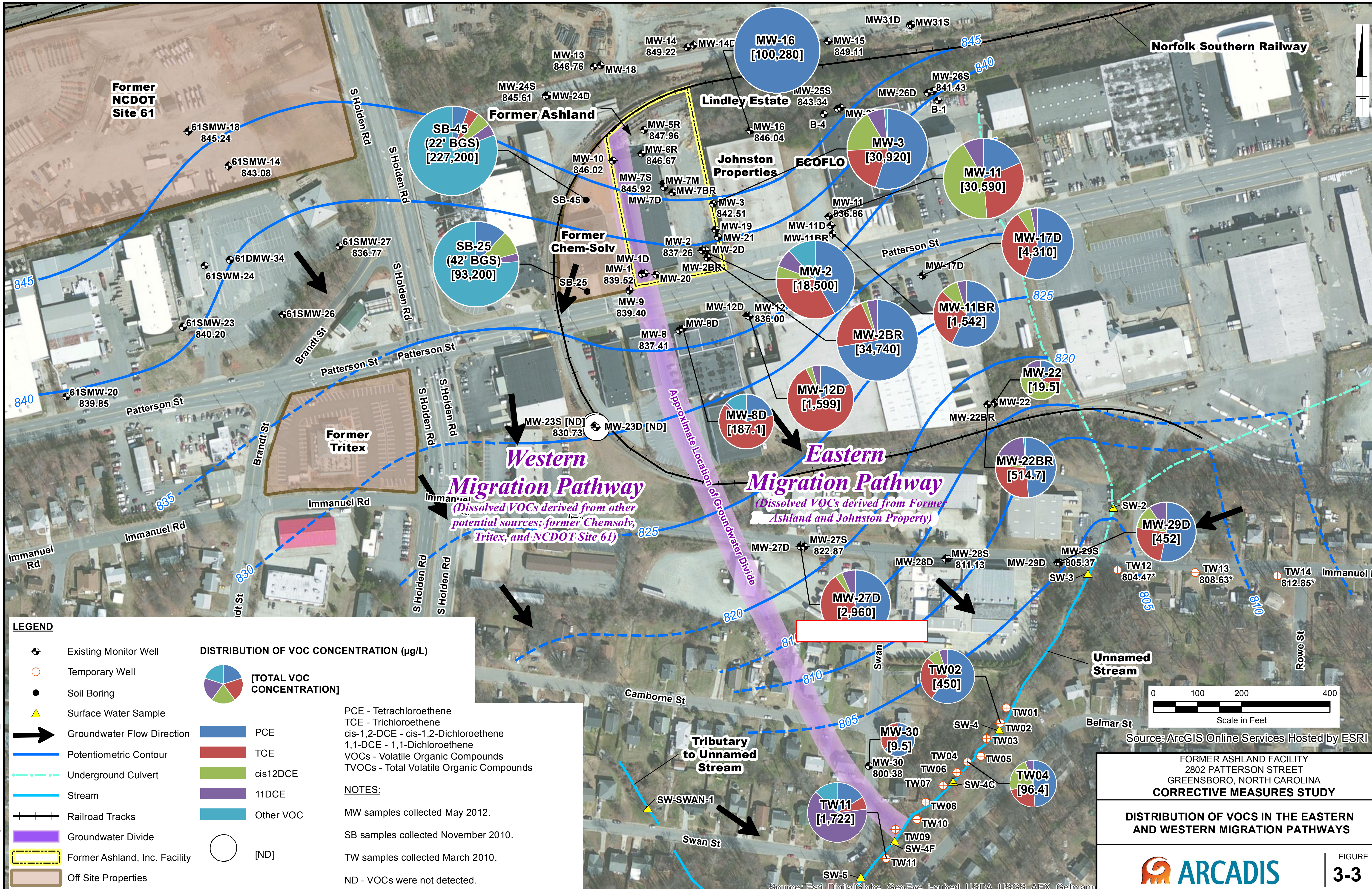

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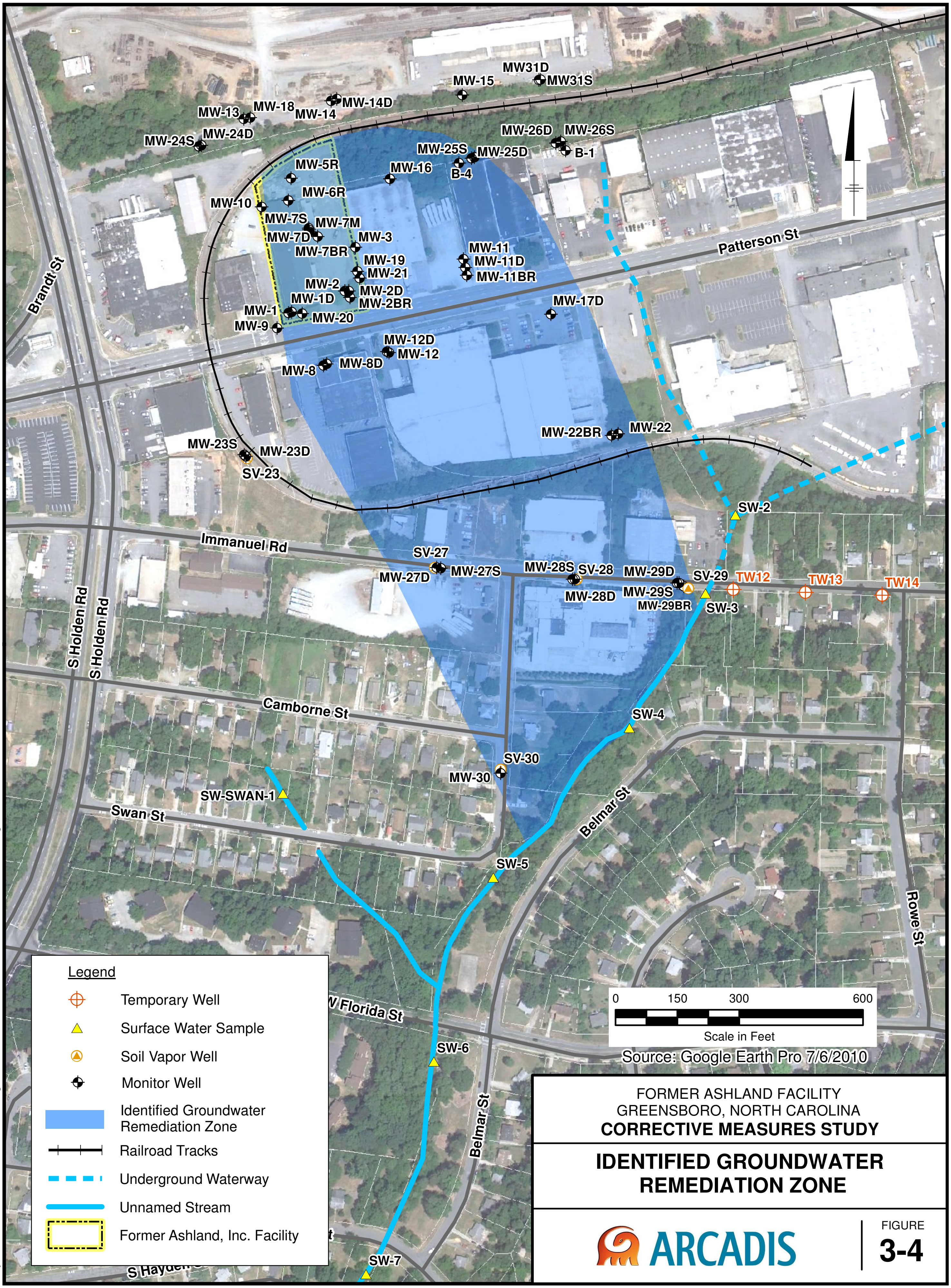

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Notes:
Excavation would require sheet piling or "alternating row excavations"[1] along building walls adjacent to remediation zones.
1: Alternating row excavations are performed by removing alternating, bucket-wide rows along the building. One row would be excavated and filled prior to excavating the next row.

FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA
CORRECTIVE MEASURES STUDY

SCMA-3: EXCAVATION WITH OFF-SITE DISPOSAL, BACKFILL WITH IMPORTED SOIL, AND INSTITUTIONAL CONTROLS

ARCADIS

FIGURE
5-1

CITY: AUGUSTA DIV/GROUP: ENV DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
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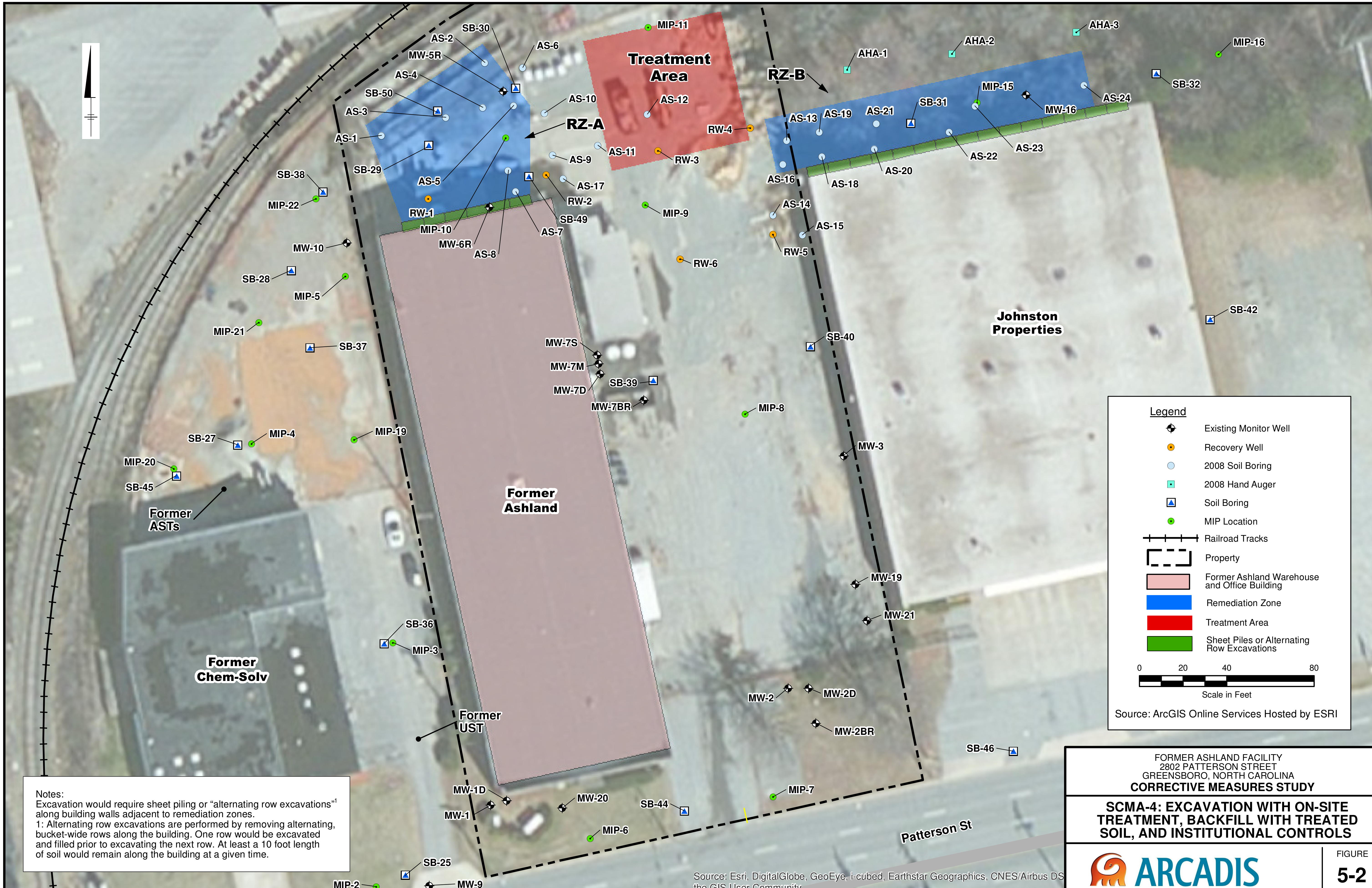

Notes:
Excavation would require sheet piling or "alternating row excavations"[1] along building walls adjacent to remediation zones.
1: Alternating row excavations are performed by removing alternating, bucket-wide rows along the building. One row would be excavated and filled prior to excavating the next row. At least a 10 foot length of soil would remain along the building at a given time.

FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA

CORRECTIVE MEASURES STUDY

SCMA-4: EXCAVATION WITH ON-SITE TREATMENT, BACKFILL WITH TREATED SOIL, AND INSTITUTIONAL CONTROLS

ARCADIS

FIGURE
5-2

CITY: AUGUSTA DIV/GROUP: ENV DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
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Notes:
Soil mixing would require sheet piling or “alternating row mixing”[1] along building walls adjacent to remediation zones.
1: Alternating row mixing is performed by mixing alternating, bucket-wide rows along the building. One row would be mixed and filled prior to mixing the next row.

FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA
CORRECTIVE MEASURES STUDY

SCMA-5: IN-SITU SOIL SOLIDIFICATION AND INSTITUTIONAL CONTROLS

ARCADIS

FIGURE
5-3

CITY: AUGUSTA DIV/GROUP: ENV DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
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FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA
CORRECTIVE MEASURES STUDY

SCMA-6: IN-SITU THERMAL DESORPTION AND INSTITUTIONAL CONTROLS

ARCADIS

FIGURE
5-4

CITY: AUGUSTA DIV/GROUP: ENV DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
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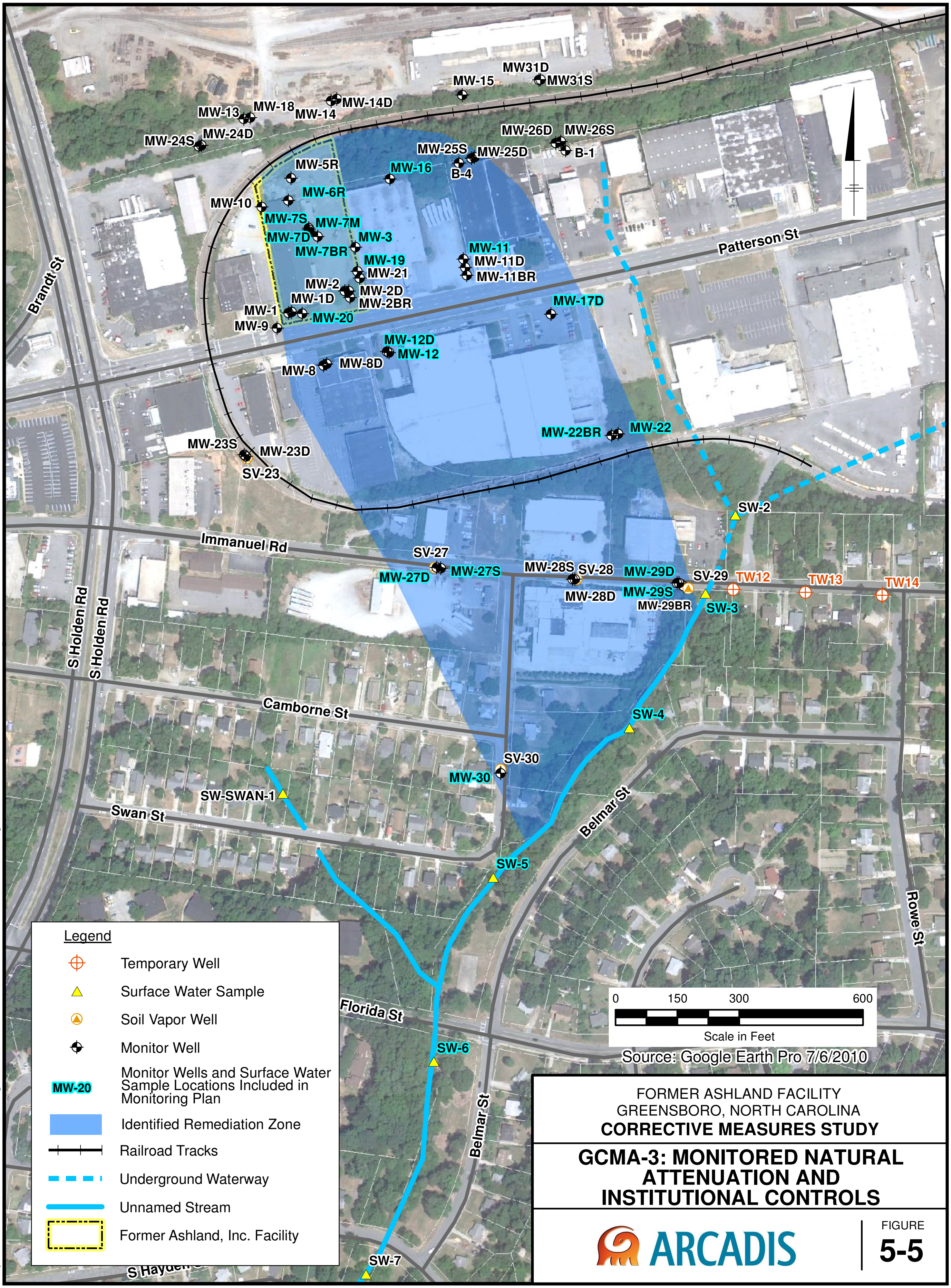

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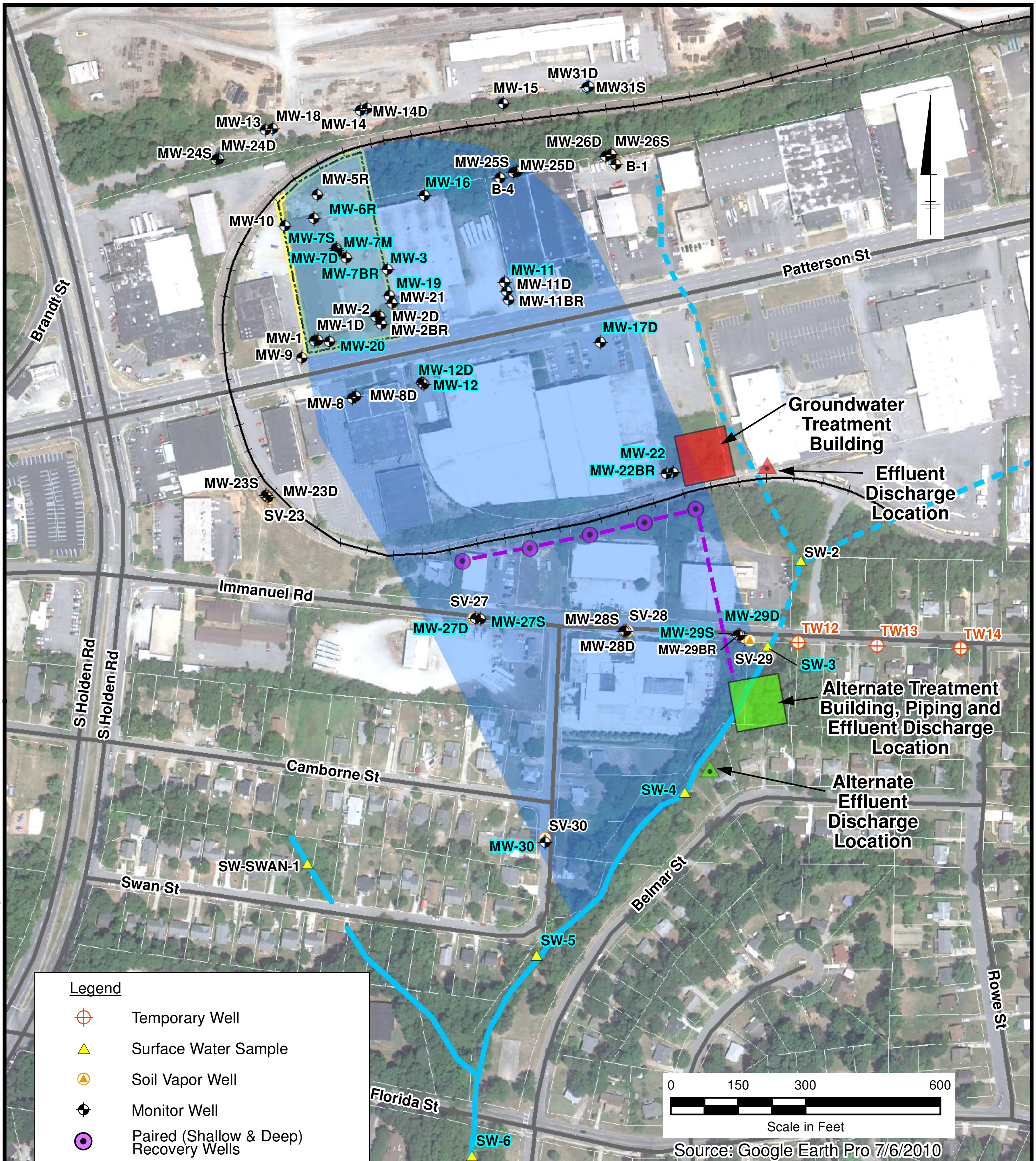


FORMER ASHLAND FACILITY
GREENSBORO, NORTH CAROLINA
CORRECTIVE MEASURES STUDY

GCMA-4: GROUNDWATER RECOVERY, TREATMENT AND DISCHARGE TO SURFACE WATER; AND INSTITUTIONAL CONTROLS

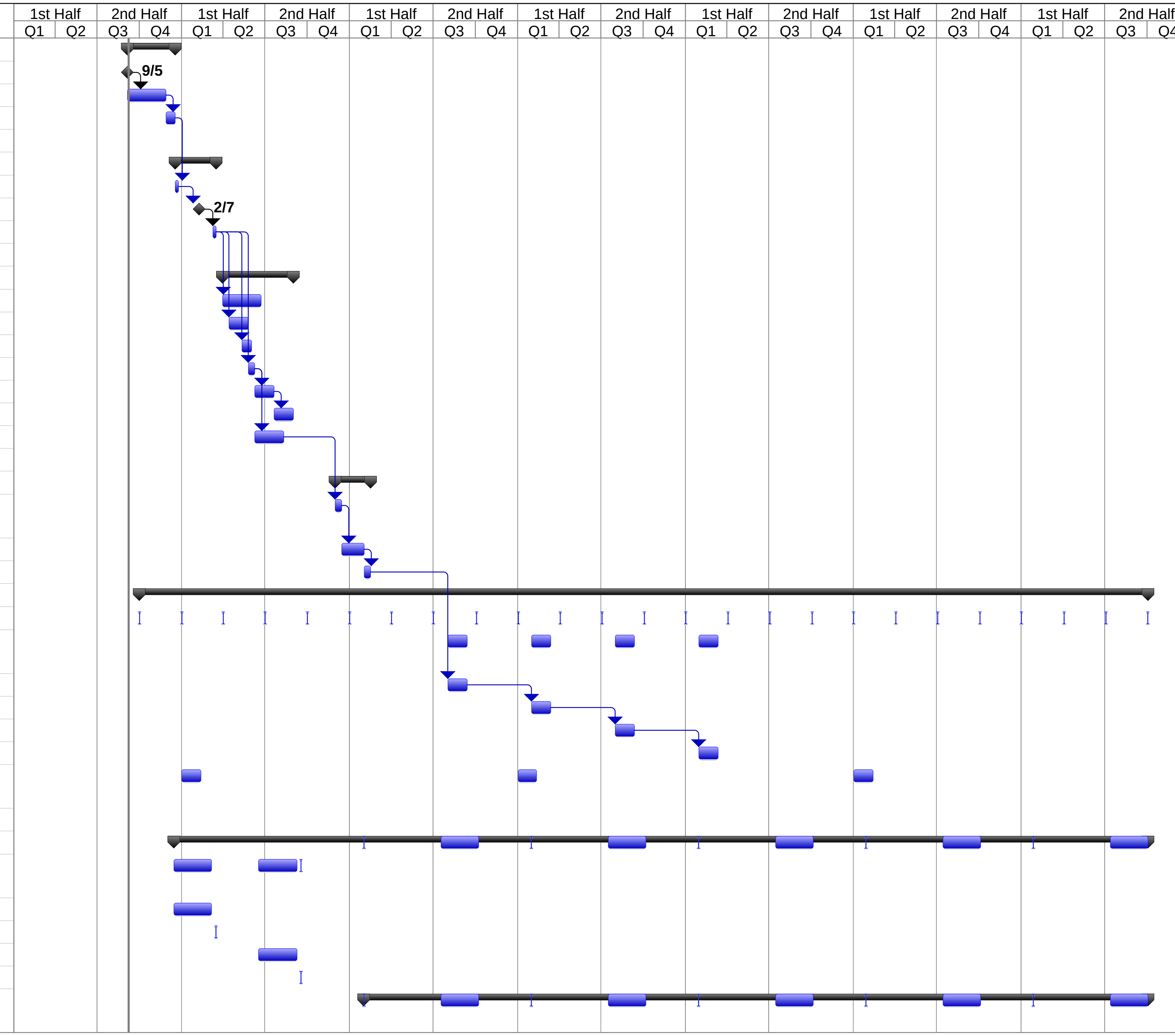
ARCADIS

FIGURE
5-6

CITY: AUGUSTA DIV/GROUP: ENV DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
Project Number: Path: G:\ENVCAD\Augusta-GA\ACT\OH007000\NC0714100\CMS Investigation\5-6_OH007000B04.mxd Date Saved: 8/26/2014 11:07:48 AM

Figure 6-1. Schedule for Corrective Measures Implementation, Ashland Inc., Greensboro, North Carolina.

ID	WBS	Task Name	Duration	Start	Finish	Predecessors
1	**1**	**CMS Report Preparation**	**74 days**	**Fri 9/5/14**	**Wed 12/17/14**	
2	1.1	Submit draft CMS Report to NCDENR	0 days	Fri 9/5/14	Fri 9/5/14	
3	1.2	NCDENR Review Period	60 days	Fri 9/5/14	Thu 11/27/14	2
4	1.3	Finalize CMS Report, and submit to NCDENR	14 days	Fri 11/28/14	Wed 12/17/14	3
5						
6	**2**	**Public Participation**	**63 days**	**Thu 12/18/14**	**Mon 3/16/15**	
7	2.1	Post Public Participation Period	1 wk	Thu 12/18/14	Wed 12/24/14	4
8	2.2	Hold Public Meeting	0 days	Sat 2/7/15	Sat 2/7/15	7FS+45 edays
9	2.3	Finalize Remedy	1 wk	Tue 3/10/15	Mon 3/16/15	8FS+30 edays
10						
11	**3**	**Corrective Measure Preparations**	**110 days**	**Tue 3/31/15**	**Mon 8/31/15**	
12	3.1	Geotechnical and Building Structural Assessment	60 days	Tue 3/31/15	Mon 6/22/15	**9FS+10 days**
13	3.2	Stormwater Management Plan	30 days	Tue 4/14/15	Mon 5/25/15	**9FS+20 days**
14	3.3	Health and Safety Plan	15 days	Tue 5/12/15	Mon 6/1/15	**9FS+40 days**
15	3.4	Remedial Construction Drawings	10 days	Tue 5/26/15	Mon 6/8/15	**9FS+50 days**
16	3.5	Corrective Measure Work Plan	30 days	Tue 6/9/15	Mon 7/20/15	**15**
17	3.6	Coordination with Property Owners	30 days	Tue 7/21/15	Mon 8/31/15	**16**
18	3.7	Contractor Procurement	45 days	Tue 6/9/15	Mon 8/10/15	**15**
19						
20	**4**	**Corrective Measure Implementation**	**55 days**	**Tue 12/1/15**	**Mon 2/15/16**	
21	4.1	Site Preparation - Concrete Removal, Stormwater Control, Etc.	10 days	Tue 12/1/15	Mon 12/14/15	**18FS+80 days**
22	4.2	ISSS	35 days	Tue 12/15/15	Mon 2/1/16	**21**
23	4.3	Site Restoration	10 days	Tue 2/2/16	Mon 2/15/16	**22**
24	**5**	**SSD System O&M and**	**1568 days**	**Wed 10/1/14**	**Fri 10/2/20**	
25	5.1	Quarterly SSD O&M Events through 2029	1568 days	Wed 10/1/14	Fri 10/2/20	
51	5.2	Semi-Annual Remedial Performance Monitoring and Site Inspections for 2 Years	420 days	Tue 8/2/16	Mon 3/12/18	
52	5.2.1	Monitoring Event 1	30 days	Tue 8/2/16	Mon 9/12/16	23FS+6 mons
53	5.2.2	Monitoring Event 2	30 days	Tue 1/31/17	Mon 3/13/17	52FS+5 mons
54	5.2.3	Monitoring Event 3	30 days	Tue 8/1/17	Mon 9/11/17	53FS+5 mons
55	5.2.4	Monitoring Event 4	30 days	Tue 1/30/18	Mon 3/12/18	54FS+5 mons
56	5.3	Biennial Vapor Intrusion Evaluations through 2029	1074 days	Thu 1/1/15	Tue 2/12/19	
60						
61	**6**	**Groundwater Monitoring and Reporting**	**1515 days**	**Mon 12/15/14**	**Fri 10/2/20**	
62	6.1	Semi-Annual Groundwater & Quarterly Surface Water Sampling/Reporting	199 days	Mon 12/15/14	Thu 9/17/15	
63	6.1.1	December 2014 GW and SW Event	60 days	Mon 12/15/14	Fri 3/6/15	
64	6.1.2	March 2015 SW Event	1 day	Mon 3/16/15	Mon 3/16/15	
65	6.1.3	June 2015 GW and SW Event	60 days	Wed 6/17/15	Tue 9/8/15	
66	6.1.4	September 2015 SW Event	1 day	Thu 9/17/15	Thu 9/17/15	
67	6.2	Annual Groundwater & Semi-Annual Surface Water Sampling and Reporting	1220 days	Mon 2/1/16	Fri 10/2/20	



Project: Figure 7-1. CMS Implementati
Date: Mon 9/8/14

Task; Split; Milestone; Summary; Project Summary; External Tasks; External Milestone; Inactive Task; Inactive Milestone; Inactive Summary; Manual Task; Duration-only; Manual Summary Rollup; Manual Summary; Start-only; Finish-only; Progress; Deadline

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Appendix A.

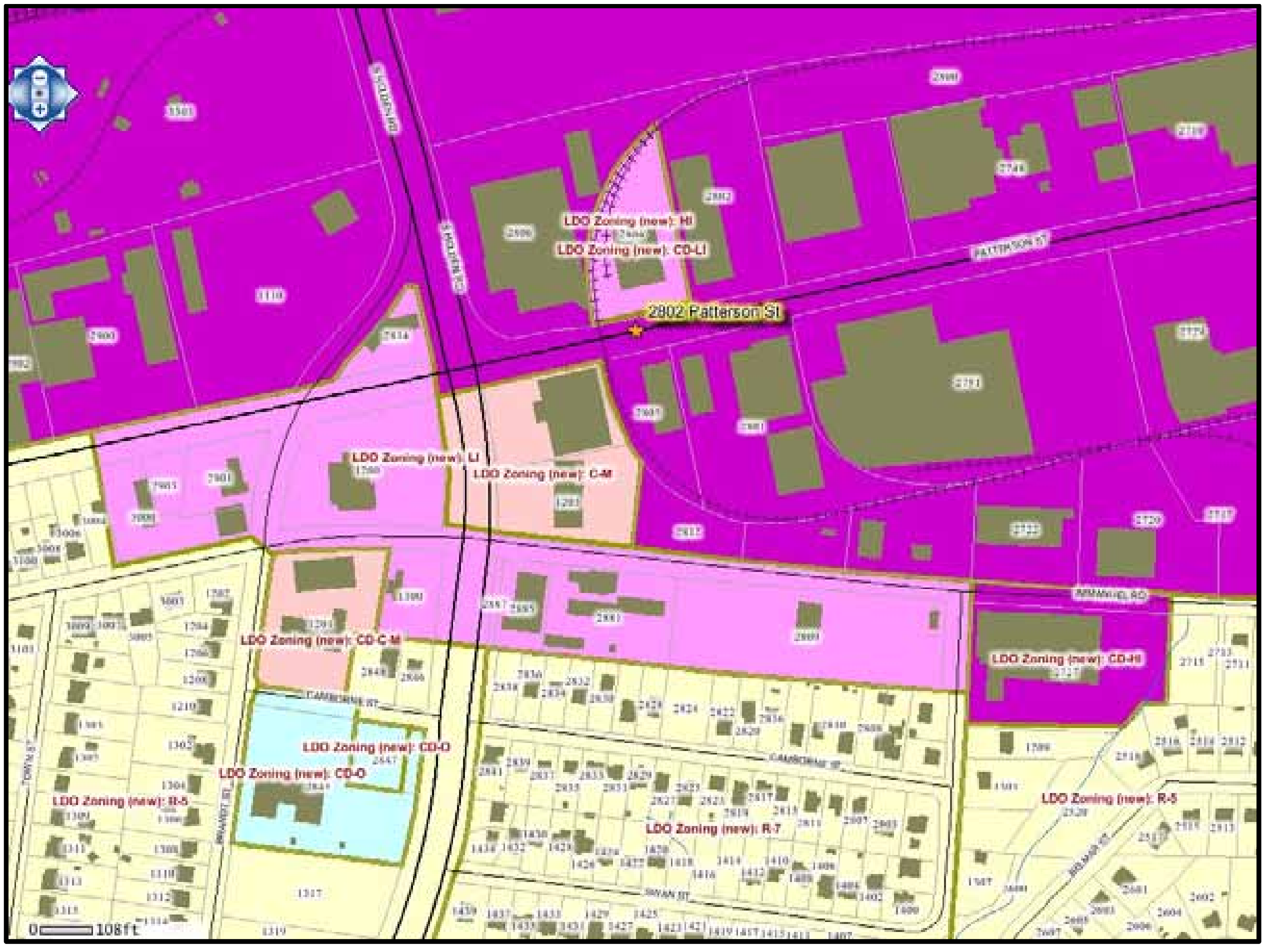
Property Zoning Map

APPENDIX A

ZONING AND PERMITTED USE OF NEARBY PROPERTIES

FORMER ASHLAND DISTRIBUTION FACILITY (EPA ID: NCD 024 599 011)

2802 PATTERSON STREET, GREENSBORO, NORTH CAROLINA



Source: Map image obtained from: http://images.greensboro-nc.gov/maingisviewer/default.htm

Legend:

- HI – Light or Heavy Industrial
- CD-LI – Light Industrial
- C-M – Office, Retail, and Commercial Uses
- CD-HI – Office, Retail, and Commercial Uses including Light or Heavy Industrial
- R-7 - Single-family Detached Dwellings

Source: Article 8: District Use Requirements, Sec. 30-8-1: Permitted Use Table obtained from http://www.greensboro-nc.gov/modules/showdocument.aspx?documentid=7620

ARCADIS

Appendix B

Timeline Summarizing Historic Investigations

TABLE B-1. SUMMARY OF HISTORICAL INVESTIGATIONS CONDUCTED AT THE SITE.
FORMER ASHLAND DISTRIBUTION FACILITY (EPA ID: NCD 024 599 011)
2802 PATTERSON STREET, GREENSBORO, NORTH CAROLINA

Investigation	Date	Area Investigated	Activities completed	Results	Reference
Hydrogeologic Investigation (TM Gates)	1988	- On-Site, shallow soil and groundwater	- 7 Shallow Wells Installed - 33 soil samples	Highest soil and groundwater VOC concentrations identified in northwest corner of the facility near MW-5 & MW-6 and around MW-3.	T.M. Gates. 1988. Hydrogeologic Investigation Report for the Ashland Chemical Company Industrial Chemicals and Solvents Division.
Subsurface Investigation (Sirrine)	1992	- On-Site, intermediate soil and groundwater - Off-Site shallow groundwater	- 9 off-Site wells on surrounding properties - 2 on-Site wells - 10 soil borings on Lindley Estate	- High PCE concentrations identified on Lindley Estate. - Groundwater impacts identified in intermediate zone on-Site. - Impacts at off-Site wells indicates other potential off-Site sources.	Sirrine Environmental Consultants. 1992. Subsurface Investigation Report.
(Sirrine)	1993	- Off-Site, intermediate groundwater	- 6 off-Site wells on surrounding properties	- Expanded monitor well network	None
Additional Soil Investigation of Underground Hazardous Waste Storage Tank (ESC)	1994	- On-Site soil, in vicinity of Hazardous Waste Storage UST.	- 3 soil samples adjacent to former Hazardous Waste Storage UST.	- VOCs detected in all soil samples. - Results used to design RCRA cap.	Environmental Strategies Corporation. 1994. Summary of Additional Soil Investigation of the Former Underground Hazardous Waste Storage Tank.
Groundwater Assessment (Woodward-Clyde)	1995	- On-site, deep groundwater - Off-Site, deep groundwater, up gradient.	- 1 deep well on Norfolk Southern property - 2 deep wells on-Site, south end	- Groundwater impacts in deep on-Site wells indicates that VOC and SVOC constituents have migrated vertically into the PWR.	Woodward-Clyde. 1995. Groundwater Assessment Report.
Phase II Groundwater Assessment	1999	-Site wide assessment of historic investigations	- Review of historic data, investigations, and groundwater monitoring results	- Identified data gaps, groundwater receptors, vapor intrusion potential. - Recommended additional investigations to further define contaminant migration pathways.	Environmental Strategies Corporation. 1999. Phase II Groundwater Assessment
Site Conceptual Model & Phase II Assessment (ESC)	2000	- On-site and off-Site monitor wells sampled.	- Summarized current understanding of Site	- Identified data gaps, groundwater receptors, vapor intrusion potential. - Consitituents detected at MW-9 suggest potential additional off-Site sources on the former Chemsolv facility.	Environmental Strategies Corporation. 2000. Site Conceptual Model and Phase II Assessment Workplan.

Notes:

Shallow	0 to 35 feet below land surface (bls)
Intermediate	35 to 60 feet bls
Deep	65 to 100 feet bls
PCE	Tetrachloroethene
UST	Underground Storage Tank
VOC	Volatile organic compound

Appendix C

Results of Corrective Measure Design Sampling

Table C-1. Characteristic Hazardous Determination Soil Analysis

	TCLP Characterist Hazardous Level (mg/L)	RZ-A-1 (4)	RZ-A-1 (8)	RZ-A-2 (3)	RZ-A-2 (8)	RZ-A-3 (3)	RZ-A-3 (8)	RZ-B-1 (3)	RZ-B-1 (8)	RZ-B-2 (3)	RZ-B-2 (8)	RZ-B-3 (3)	RZ-B-3 (8)
TCLP VOCs (mg/L)													
Chloroform	6	**0.18**	<0.020	<0.020	<0.10	<0.020	<0.020	<0.50	<0.50	<0.020	<0.020	<0.020	<0.020
PCE	0.7	<0.020	**0.055**	<0.020	**6.9**	**0.051**	<0.020	**37**	**24**	<0.020	<0.020	<0.020	<0.020
TCE	0.5	<0.020	<0.020	<0.020	**0.20**	<0.020	<0.020	**1.1**	**1.3**	<0.020	<0.020	<0.020	<0.020
All Other VOCs	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total VOCs (mg/kg)		6/5/2014	6/5/2014	6/5/2014	6/5/2014	6/5/2014	6/5/2014	6/5/2014	6/5/2014	6/5/2014	6/5/2014	6/5/2014	6/5/2014
Chloroform		NA	NA	NA	NA	<0.520	<0.0077	NA	NA	<0.0059	<0.520	NA	NA
PCE		NA	NA	NA	NA	**9.6**	**0.073**	NA	NA	**0.039**	**1.6**	NA	NA
TCE		NA	NA	NA	NA	<0.520	<0.0077	NA	NA	<0.0059	<0.520	NA	NA
Dilution Factor: Ratio of Total PCE in Soil to TCLP Concentration						188.2	>3.6			>2	80		

Summary:

Remediation Zone A - Former Ashland Property **16.5 % of samples exceeded TCLP hazardous waste levels**

Remediation Zone B - Johnston Property **33 % of samples exceeded TCLP hazardous waste levels**

Notes:
mg/L - milligram per liter
mg/kg - milligram per kilogram
TCLP - Toxicity Characteristic Leaching Procedure
PCE - tetrachloroethene
TCE - Trichloroethene
VOCs - Volatile Organic Compounds
NA - Not Applicable
ND - Not detected
< - Indicated constituent was not detected at the reporting limit presented

Table C-2. ISSS Bulking Calculations

Mix Number	Sample Location	Mix Description	R	Density insitu* (g/cm3)	MC insitu	Density treated (g/cm3)	MC treated	Bulking Factor
Zone A - B1	Remediation Zone A	5% PC (low density estimate)	0.05	1.3	23.08%	1.71	35.16%	-0.1
		5% PC (high density estimate)	0.05	1.9	23.08%	1.71	35.16%	0.3
Zone A - B2		20% PC (low density estimate)	0.2	1.3	23.08%	1.74	29.34%	-0.1
		20% PC (high density estimate)	0.2	1.9	23.08%	1.74	29.34%	0.4
Zone B - B1	Remediation Zone B	5% PC (low density estimate)	0.05	1.3	26.31%	1.63	49.76%	0.0
		5% PC (high density estimate)	0.05	1.9	26.31%	1.63	49.76%	0.5
Zone B - B2		20% PC (low density estimate)	0.2	1.3	26.31%	1.69	42.99%	0.0
		20% PC (high density estimate)	0.2	1.9	26.31%	1.69	42.99%	0.5

Average Bulking Factor =	0.2

Notes:
PC - Portland Cement
R - Dry weight ratio of solidifying agent to soil
MC - Moisture Content
* Typical in-situ densities of silts were obtained from "Remediation Hydraulics" Table 2.3

(2) Bulking Factor. The bulking factor is the amount of volume increase that will occur as a result of the addition of treatment reagents. Frequently a maximum allowable bulking factor will be one of the criteria established for a treatability study. The following equation can be used to determine the bulking factor (B):

$$B = (1 + R) * \frac{D\ insitu}{D\ treated} * \frac{1 + MC\ treated}{1 + MC\ insitu} - 1$$

R = Dry weight ratio of solidifying agent to waste
D insitu = Bulk unit weight of insitu waste
D treated = Bulk unit weight of compacted treated material
MC insitu = Moisture content of insitu waste
MC treated = Moisture content of treated material

Table C-3. ISSS Mixture Strength

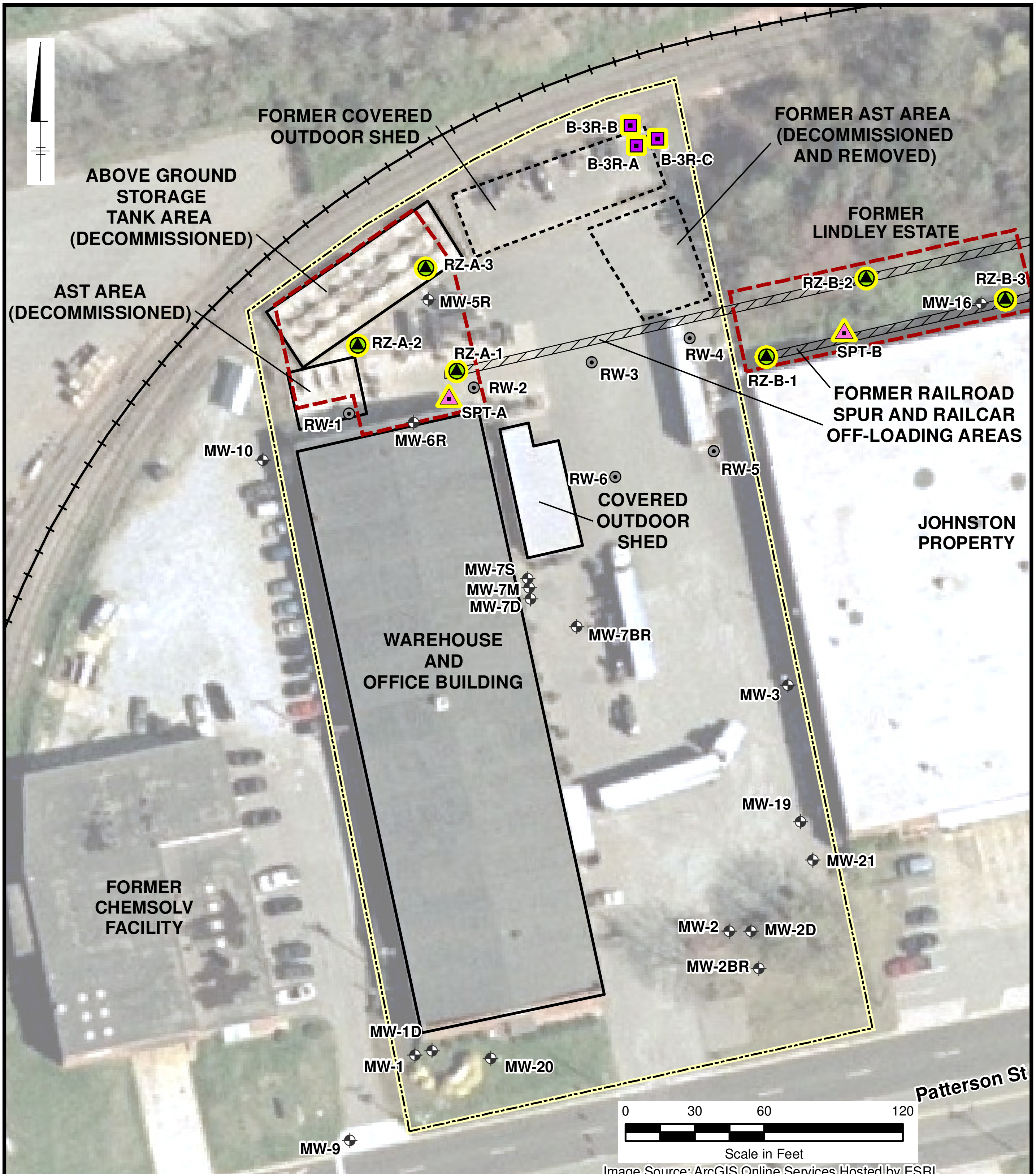
Ashland Greensboro ISSS Treatability Study Pretest - Pocket Penetrometer Data (1 TSF = 13.89 psi)					
Sample ID	Material	Mix Description	Pocket Penetrometer Reading (tsf)		
			Day 6	Day 7	Day 17
Zone A - B1	Zone A	5% PC	> 4.5	> 4.5	> 4.5
Zone A - B2		20% PC	> 4.5	> 4.5	> 4.5
Zone B - B1	Zone B	5% PC	0.75	0.75	1.0
Zone B - B2		20% PC	> 4.5	> 4.5	> 4.5

Notes:
PC - Portland Cement
TSF - tons per square foot
PSI - pounds per square inch

Table C-4. Confirmation of Historical Sample Results from Soil Sample Collected at B-3 (T.M. Gates, Inc., 1988)

	NCDENR Industrial PSRGs	Sample ID:	B-3	B-3R-A	B-3R-B	B-3R-C
VOCs (mg/kg) - USEPA Test Method 8260B		Date:	1988*	6/5/2014	6/5/2014	6/5/2014
PCE	82		**590**	<0.0062	<0.0086	<0.0075
TCE	4		ND	<0.0062	<0.0086	<0.0075
Ethylbenzene	27		**6.1**	<0.0062	<0.0086	<0.0075
Toluene	820		**2.1**	<0.0062	<0.0086	<0.0075
Xylenes	260		**7.6**	<0.012	<0.017	<0.015

Notes:
VOCs - Volatile Organic Compounds
mg/kg - milligram per kilogram
NCDENR Industrial PSRG - North Carolina Department of Environment and Natural Resources - Preliminary Soil Remediation Goals for Industrial Soil
PCE - tetrachloroethene
TCE - Trichloroethene
Sample B-3 Reference: T.M. Gates, Inc., 1988. Hydrologic Investigation Report. Ashland Chemical Company. March 30, 1988.
* - No sample date was listed in report



Legend

- Soil Sample 2-ft Depth
- Sample Location (2'-3' & 7'-8' bgs)
- SPT Boring (to 12' bgs)
- Monitor Well
- ART Recovery Well
- Existing Area
- Former Area
- Former Spur
- Approximate Extent of Remediation Zone
- Property
- Railroad Tracks

FORMER ASHLAND FACILITY
2802 PATTERSON STREET
GREENSBORO, NORTH CAROLINA
CMS INVESTIGATION

SITE LAYOUT SHOWING REMEDIAL ZONES AND SOIL BORING LOCATIONS

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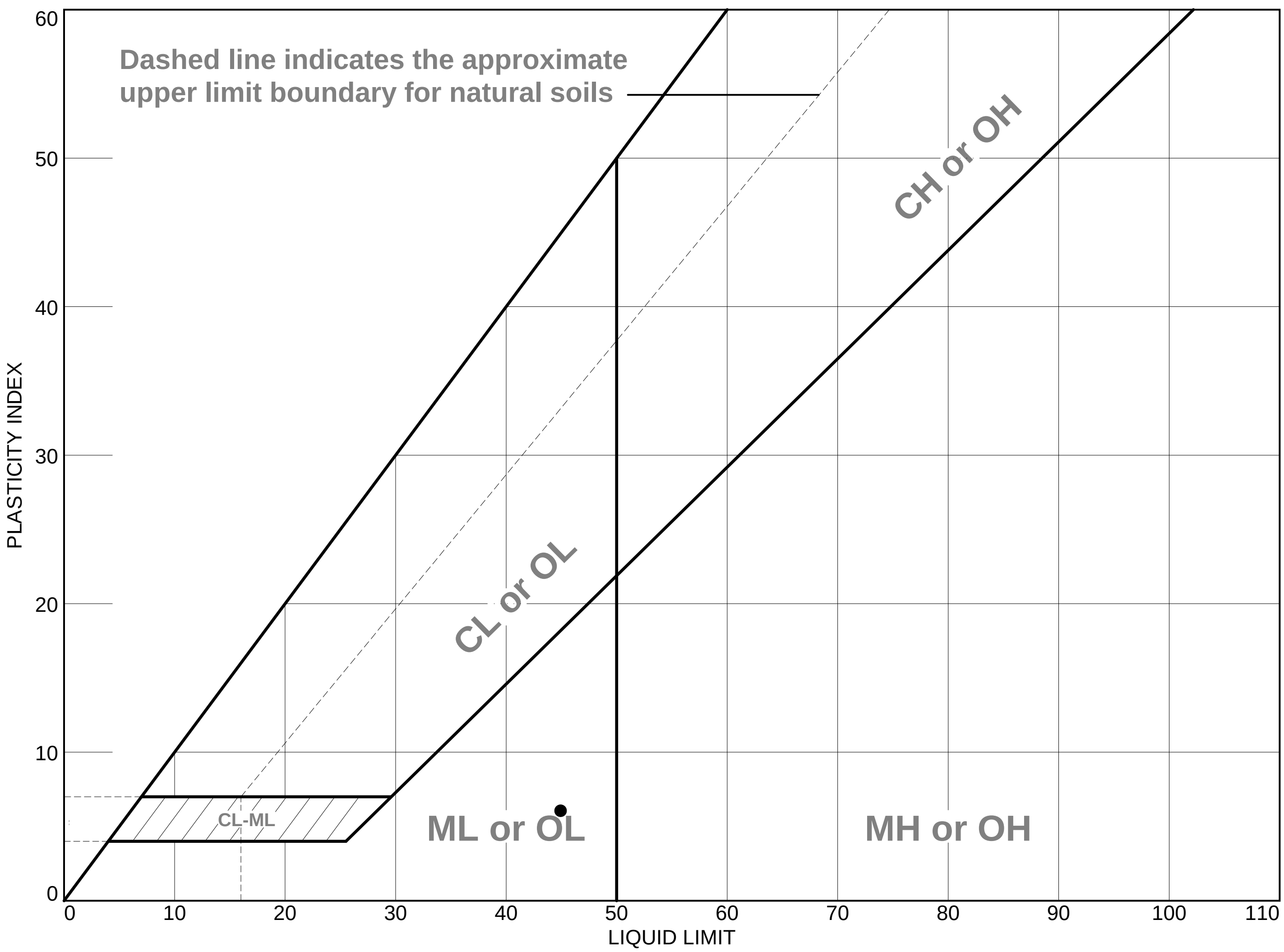
FIGURE
C-1

CITY: AUGUSTA DIV/GROUP: ENV/GIS DB: A. Saul LD: A. Saul PIC: PM: TM: TR:
Path: G:\ENVCAD\Augusta-GA\ACT\OH007000\NC07141001\CMS Investigation\Other Figures\01_OH07000B01.mxd Date Saved: 7/14/2014 5:49:37 PM BY: SAUL, ANNE

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Red Tan Fine Sandy SILT	45	39	6			ML

Project No. 24388 **Client:** ARCADIS

Project: Ashland-Greensboro

●**Source:** SPT-A **Depth:** 11.00-13.00 **Sample No.:** D4S-1

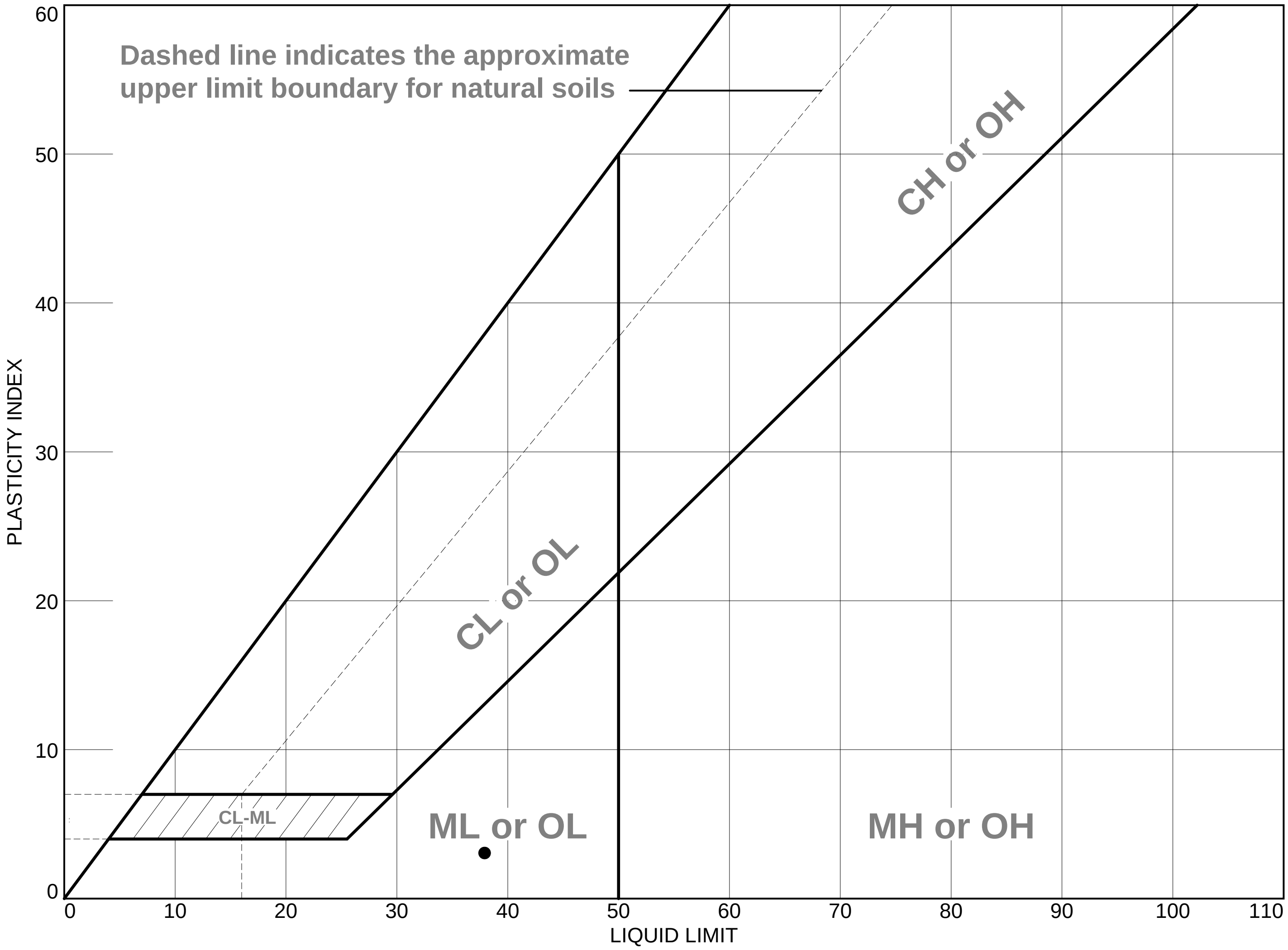
Remarks:

Specific Gravity-2.63
PH-3.7

ECS CAROLINAS, LLP
4811 Koger Boulevard
Greensboro, NC 27407
Phone: (336) 856-7150
Fax: (336) 856-7160

Figure C-2

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Red Tan Fine Sandy SILT	38	35	3			ML

Project No. 24388 **Client:** ARCADIS

Project: Ashland-Greensboro

●**Source:** SPT-B **Depth:** 11.00-13.00 **Sample No.:** D4S-2

Remarks:

Specific Gravity-2.60
PH-6.7

ECS CAROLINAS, LLP
4811 Koger Boulevard
Greensboro, NC 27407
Phone: (336) 856-7150
Fax: (336) 856-7160

Figure C-3

ARCADIS

SOIL CORE / SAMPLING LOG

Boring/Well SPT-A Project/No. OH007000.NC07.14300 Page 1 of 1

Site Location Ashland - Greensboro, NC Drilling Started 6/5/2014 Drilling Completed 6/5/2014

Drilling Contractor Parratt-Wolff, Inc. Driller J. Ellingsworth Helper P. Phillips

Drilling Fluid Used None Drilling Method Hand Auger/HSA

Length and Diameter of Coring Device 2' Split spoon Sampling Interval 2 feet

Land-Surface Elev. NA feet ☐ Surveyed ☐ Estimated Datum NA

Total Depth Drilled 13 Feet Hole Diameter 4" Coring Device

Prepared By Dan Rhodes/ Matt Webb Hammer Weight 140 lbs. Hammer Drop 30 ins.

Sampling Data:

Depth	Grab/Composite	Time	Laboratory Analysis
11.0'-13.0'	Grab	0945	Atterberg Limits & Specific Gravity

Soil Characterization:

Sample/Core Depth (Feet bls) From	To	Core Recovery (Feet)	PID Reading (ppm)	Blow Counts per 6 Inches	Sample/Core Description
0.0	1.0	NA	NA	NA	Concrete
1.0	3.0	NA	1800.0	NA	Organic material - wood from railroad tie.
3.0	4.5	NA	268.5	NA	Reddish brown (10R 4/6) micaceous silt with some clay (<30%). Some
					organics (wood, ~40%). SAPROLITE
4.5	5.0	NA	65.7	NA	Same as above (SAA) - No organics (wood). Small, 1-5 mm light tan clay
					balls (~20%-30%). Dry. SAPROLITE
5.0	7.0	1.0	95.3	0-0-0-0	SAA - Clay ball size >5 mm, some sand (~20%). Moist. SAPROLITE
7.0	9.0	2.0	61.2	2-3-2-4	SAA - Becoming more mottled. Some relict igneous plutonic texture.
					Increasing sand content (>20%). Concentration of yellow to brown sand and
					silt @ approximately 8.0'. Moist. SAPROLITE
9.0	11.0	1.8	2.4	2-2-2-2	SAA - Increase in sand content (30%-40%). Alternating layers of red silt and
					tan sandy silt (1-3 mm thick). Moist. SAPROLITE
11.0	13.0	2.0	0.6	2-3-3-4	Red Brown (10R 4/6) micaceous soft clay with some silt. High plasticity,
					Moist to wet. Last 0.5' is tan to red brown, medium stiff, clay and silt. Low
					to medium plasticity. Interlayered red brown and tan silt. SAPROLITE
					Total Depth - 13.0'

FIGURE C-4

SOIL CORE / SAMPLING LOG

Boring/Well SPT-B Project/No. OH007000.NC07.14300 Page 1 of 1

Site Location Ashland - Greensboro, NC Drilling Started 6/5/2014 Drilling Completed 6/5/2014

Drilling Contractor Parratt-Wolff, Inc. Driller J. Ellingsworth Helper P. Phillips

Drilling Fluid Used None Drilling Method Hand Auger/HSA

Length and Diameter of Coring Device 2' Split spoon Sampling Interval 2 feet

Land-Surface Elev. NA feet ☐ Surveyed ☐ Estimated Datum NA

Total Depth Drilled 13 Feet Hole Diameter 4" Coring Device

Prepared By Dan Rhodes/ Matt Webb Hammer Weight 140 lbs. Hammer Drop 30 ins.

Sampling Data:

Depth	Grab/Composite	Time	Laboratory Analysis
11.0'-13.0'	Grab	1510	Atterberg Limits & Specific Gravity

Soil Characterization:

Sample/Core Depth (Feet bls) From	To	Core Recovery (Feet)	PID Reading (ppm)	Blow Counts per 6 Inches	Sample/Core Description
0.0	1.0	NA	NA	NA	Brown to dark brown (10 R 3/2) silt and sand. Some organics (plant).
1.0	5.0	NA	2.8	NA	Brown to reddish brown, mottled (10 R 4/6) silt with some clay (~30%)
5.0	7.0	2	84.0	0-1-3-3	Same as above (SAA) - higher clay content (~40%). Yellow (7.5 YR 8/6)
					sandy clay lense at 6.0'. SAPROLITE
7.0	9.0	2	7.7	3-4-5-6	SAA - thin, ~1 mm thick sandy layers becoming prevalent. SAPROLITE
9.0	11.0	2	1.6	4-5-6-7	SAA
11.0	13.0	2	27.5	4-5-7-11	SAA - increase in sand (~30%-40%) 12.5' - 13.0'
					Total Depth - 13.0'

FIGURE C-5

SOIL CORE / SAMPLING LOG

Boring/Well RZ-A-1 Project/No. OH007000.NC07.14300 Page 1 of 1

Site Location Ashland - Greensboro, NC Drilling Started 6/5/2014 Drilling Completed 6/5/2014

Drilling Contractor Parratt-Wolff, Inc. Driller J. Ellingsworth Helper P. Phillips

Drilling Fluid Used None Drilling Method Hand Auger/DPT

Length and Diameter of Coring Device 5' Macrocore Sampling Interval Continuous feet

Land-Surface Elev. NA feet ☐ Surveyed ☐ Estimated Datum NA

Total Depth Drilled 8.5 Feet Hole Diameter 2.25" Coring Device

Prepared By Dan Rhodes/ Matt Webb Hammer Weight NA Hammer Drop NA ins.

Sampling Data:

Depth	Grab/Composite	Time	Laboratory Analysis
4.0	Grab	1040	TCLP VOCs
8.0	Grab	1105	TCLP VOCs

Soil Characterization:

Sample/Core Depth (Feet bls) From	To	Core Recovery (Feet)	PID Reading (ppm)	Blow Counts per 6 Inches	Sample/Core Description
0.0	1.0	NA	NA	NA	Concrete
1.0	3.0	NA	NA	NA	Aggregate base - fine to coarse gravel and sand.
3.0	5.0	NA	0.3	NA	Olive (5Y 5/6) with yellow (5Y 8/8) fine to coarse sand with fine gravel and
					some silt/clay.
5.0	8.5	1.5	7.8	NA	Same as above (SAA) - 3" layer of sand from 6.75' to 7.0'.
					Total Depth - 8.5'

FIGURE C-6

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SOIL CORE / SAMPLING LOG

Boring/Well RZ-A-2 Project/No. OH007000.NC07.14300 Page 1 of 1

Site Location Ashland - Greensboro, NC Drilling Started 6/5/2014 Drilling Completed 6/5/2014

Drilling Contractor Parratt-Wolff, Inc. Driller J. Ellingsworth Helper P. Phillips

Drilling Fluid Used None Drilling Method Hand Auger/DPT

Length and Diameter of Coring Device 5' Macrocore Sampling Interval Continuous feet

Land-Surface Elev. NA feet ☐ Surveyed ☐ Estimated Datum NA

Total Depth Drilled 10 Feet Hole Diameter 2.25" Coring Device

Prepared By Dan Rhodes/ Matt Webb Hammer Weight NA Hammer Drop NA ins.

Sampling Data:

Depth	Grab/Composite	Time	Laboratory Analysis
3.0	Grab	1130	TCLP VOCs
8.0	Grab	1145	TCLP VOCs

Soil Characterization:

Sample/Core Depth (Feet bls) From	To	Core Recovery (Feet)	PID Reading (ppm)	Blow Counts per 6 Inches	Sample/Core Description
0.0	0.3	NA	NA	NA	Asphalt
0.3	0.5	NA	NA	NA	Aggregate - sand and silt
0.5	0.8	NA	NA	NA	Concrete
0.8	3.0	NA	0.3	NA	Brown to light brown (7.5 YR 6/8) micaceous silt to fine sand (30%-40%). Dry.
					SAPROLITE
3.0	5.0	NA	NA	NA	Yellow brown (7.5 YR 7/8) fine sand with some silt and clay (~30%). Dry.
					SAPROLITE
5.0	10.0	3.0	21.5	NA	5.0-6.5 - No recovery
					6.5'-7.0' - Orange to yellow orange (7.5 YR 7/6) fine sand with ~40% silt/clay.
					7.0'-10.0' - Reddish brown to mottled olive silt with some clay (~30%).
					Micaceous. Silt increase 9.5'-10'. SAPROLITE
					Total Depth - 10.0'

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SOIL CORE / SAMPLING LOG

Boring/Well RZ-A-3 Project/No. OH007000.NC07.14300 Page 1 of 1

Site Location Ashland - Greensboro, NC

Drilling Started 6/5/2014 Drilling Completed 6/5/2014

Drilling Contractor Parratt-Wolff, Inc. Driller J. Ellingsworth Helper P. Phillips

Drilling Fluid Used None Drilling Method Hand Auger/DPT

Length and Diameter of Coring Device 5' Macrocore Sampling Interval Continuous feet

Land-Surface Elev. NA feet ☐ Surveyed ☐ Estimated Datum NA

Total Depth Drilled 10 Feet Hole Diameter 2.25" Coring Device

Prepared By Dan Rhodes/ Matt Webb Hammer Weight NA Hammer Drop NA ins.

Sampling Data:

Depth	Grab/Composite	Time	Laboratory Analysis
3.0	Grab	1400	TCLP VOCs & Total VOCs
8.0	Grab	1415	TCLP VOCs & Total VOCs

Soil Characterization:

Sample/Core Depth (Feet bls) From	To	Core Recovery (Feet)	PID Reading (ppm)	Blow Counts per 6 Inches	Sample/Core Description
0.0	0.3	NA	NA	NA	Concrete
0.3	4.0	NA	2.0	NA	Red to red brown (5 YR 4/6) micaceous silt with some clay (~30%). Some
					traces of fine sand (<30%). Dry. SAPROLITE
4.0	5.0	NA	0.6	NA	Same as above - More clay (~40%). Also some yellowish brown (10 YR 5/6)
					fine sand and silt. Creates mottling. Moist to dry. SAPROLITE
5.0	10.0	5.0	0.2	NA	Red to red brown (5 YR 4/6) micaceous silt and clay. Clay content increases
					with depth. Medium to low plasticity. Moist. Some 2-5 mm sand lenses
					SAPROLITE
					Total Depth - 10.0'

FIGURE C-8

ARCADIS

SOIL CORE / SAMPLING LOG

Boring/Well RZ-B-1 Project/No. OH007000.NC07.14300 Page 1 of 1

Site Location Ashland - Greensboro, NC Drilling Started 6/5/2014 Drilling Completed 6/5/2014

Drilling Contractor Parratt-Wolff, Inc. Driller J. Ellingsworth Helper P. Phillips

Drilling Fluid Used None Drilling Method Hand Auger/DPT

Length and Diameter of Coring Device 5' Macrocore Sampling Interval Continuous feet

Land-Surface Elev. NA feet ☐ Surveyed ☐ Estimated Datum NA

Total Depth Drilled 10 Feet Hole Diameter 2.25" Coring Device

Prepared By Dan Rhodes/ Matt Webb Hammer Weight NA Hammer Drop NA ins.

Sampling Data:

Depth	Grab/Composite	Time	Laboratory Analysis
3.0	Grab	1555	TCLP VOCs
8.0	Grab	1605	TCLP VOCs

Soil Characterization:

Sample/Core Depth (Feet bls) From	To	Core Recovery (Feet)	PID Reading (ppm)	Blow Counts per 6 Inches	Sample/Core Description
0.0	1.5	NA	NA	NA	Gray to black (10 YR 1.7/1) sand and silt with some organics (plants).
1.5	5.0	NA	NA	NA	Yellow to light yellow (7.5 YR 8/2) silt and sand with trace amounts of clay.
					(<20%). Dry. SAPROLITE
5.0	10.0	3.5	382.7	NA	Reddish brown (5 YR 5/6) to yellow (7.5 YR 8/2) silt with some sand (30%)
					Mottled from 8.0'-10.0'. Some relict igneous plutonic texture. Moist.
					SAPROLITE
					Total Depth - 10.0'

ARCADIS

SOIL CORE / SAMPLING LOG

Boring/Well RZ-B-2 Project/No. OH007000.NC07.14300 Page 1 of 1

Site Location Ashland - Greensboro, NC

Drilling Started 6/5/2014 Drilling Completed 6/5/2014

Drilling Contractor Parratt-Wolff, Inc. Driller J. Ellingsworth Helper P. Phillips

Drilling Fluid Used None Drilling Method Hand Auger/DPT

Length and Diameter of Coring Device 5' Macrocore Sampling Interval Continuous feet

Land-Surface Elev. NA feet ☐ Surveyed ☐ Estimated Datum NA

Total Depth Drilled 10 Feet Hole Diameter 2.25" Coring Device

Prepared By Dan Rhodes/ Matt Webb Hammer Weight NA Hammer Drop NA ins.

Sampling Data:

Depth	Grab/Composite	Time	Laboratory Analysis
3.0	Grab	1535	TCLP VOCs & Total VOCs
8.0	Grab	1545	TCLP VOCs & Total VOCs

Soil Characterization:

Sample/Core Depth (Feet bls) From	To	Core Recovery (Feet)	PID Reading (ppm)	Blow Counts per 6 Inches	Sample/Core Description
0.0	1.0	NA	NA	NA	Gray to black (10 YR 1.7/1) sand and silt with some organics (plants).
1.0	3.0	NA	0.2	NA	Brownish red (10 R 5/8) silt with some clay (~30%). Some yellow
					(7.5 YR 8/2) clay balls ~2-5 mm in size. Dry to moist. SAPROLITE
5.0	10.0	4.5	0.2	NA	Same as above (SAA) - moist. 6.5'-10.0' slight increase in clay content.
					SAPROLITE
					Total Depth - 10.0'

SOIL CORE / SAMPLING LOG

ARCADIS

Boring/Well RZ-B-3 Project/No. OH007000.NC07.14300 Page 1 of 1

Site Location Ashland - Greensboro, NC

Drilling Started 6/5/2014 Drilling Completed 6/5/2014

Drilling Contractor Parratt-Wolff, Inc. Driller J. Ellingsworth Helper P. Phillips

Drilling Fluid Used None Drilling Method Hand Auger/DPT

Length and Diameter of Coring Device 5' Macrocore Sampling Interval Continuous feet

Land-Surface Elev. NA feet ☐ Surveyed ☐ Estimated Datum NA

Total Depth Drilled 10 Feet Hole Diameter 2.25" Coring Device

Prepared By Dan Rhodes/ Matt Webb Hammer Weight NA Hammer Drop NA ins.

Sampling Data:

Depth	Grab/Composite	Time	Laboratory Analysis
3.0	Grab	1515	TCLP VOCs
8.0	Grab	1520	TCLP VOCs

Soil Characterization:

Sample/Core Depth (Feet bls) From	To	Core Recovery (Feet)	PID Reading (ppm)	Blow Counts per 6 Inches	Sample/Core Description
0.0	1.0	NA	NA	NA	Gray to black (10 YR 1.7/1) sand and silt with some organics (plants).
1.0	3.0	NA	0.2	NA	Brown to red (10 R 4/6) micaceous silt and soft clay . Some yellow
					(7.5 YR 8/2) clay balls ~2-5 mm in size. Moist. SAPROLITE
5.0	10.0	3.5	0.3	NA	Same as above (SAA) - Yellow clay lense at 7.0'-7.5'. Clay content decrease
					at 9.0'. Becomes more mottled. Moist. SAPROLITE
					Total Depth - 10.0'

FIGURE C-11

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Appendix D

Corrective Measure Alternative
Cost Tables

Table D-1: Soil Corrective Measure Alternative Cost Summary Table

Ashland Greensboro Site

SCMA-1			
No Additional Action			
Task #	**Task**	**Cost**	
1	None	$	-
	0		
TOTAL		**$**	**-**

SCMA-2			
Institutional Controls - Estimated Costs			
Task #	**Task**	**Cost**	
1	IC Implementation	$	10,000
2	Long Term IC Maintenance (30 Years)	$	30,000
3	Propject Management (15% of Capital and Operation Costs)	$	6,000
TOTAL		**$**	**46,000**

SCMA-3			
Excavation, Transportation & Disposal, and ICs - Estimated Costs			
Task #	**Task**	**Cost**	
1	Design/Engineering/Regulatory Plans	$	82,500
2	Contractor Procurement/Facility Access & Coordination	$	10,000
3	Site Preparation	$	187,550
4	Excavation of Material & Disposal	$	1,146,800
5	Restoration Activities	$	106,800
6	Construction/Project Management & Monitoring	$	126,880
TOTAL		**$**	**1,707,000**
25% Excavation Contingency Costs		$	393,000
TOTAL with Contingencies		**$**	**2,100,000**

SCMA-4			
Excavation with On-Site Treatment, Backfill, and ICs - Estimated Costs			
Task #	**Task**	**Cost**	
1	Design/Engineering/Characterization/Regulatory Plans	$	110,000
2	Contractor Procurement/Facility Access & Coordination	$	17,500
3	Site Preparation	$	213,550
4	Excavation of Material & Treatment	$	994,000
5	Restoration Activities	$	75,800
6	Construction/Project Management & Monitoring	$	136,880
TOTAL		**$**	**1,500,000**
25% Excavation Contingency Costs		$	356,000
TOTAL with Contingencies		**$**	**1,900,000**

SCMA-5			
ISSS and ICs - Estimated Costs			
Task #	**Task**	**Cost**	
1	Design/Engineering/Characterization/Regulatory Plans	$	120,000
2	Contractor Procurement/Facility Access & Coordination	$	17,500
3	Site Preparation	$	204,550
4	Material Mixing & Treatment	$	345,840
5	Restoration Activities	$	61,000
6	Construction/Project Management & Monitoring	$	126,880
TOTAL		**$**	**930,000**

SCMA-6			
ISTD and ICs - Estimated Costs			
Task #	**Task**	**Cost**	
1	Design/Engineering/Characterization/Regulatory Plans	$	110,000
2	Contractor Procurement/Facility Access & Coordination	$	17,500
3	Site Preparation	$	79,000
4	Site Activities Pre Operation - Thermal Vendor	$	1,022,700
5	Operations - Thermal Vendor	$	1,864,000
6	Restoration Activities - Thermal Vendor	$	181,100
7	Utilities - Paid Directly by Client	$	379,000
8	Construction/Project Management & Monitoring	$	372,624
TOTAL		**$**	**4,100,000**
Thermal Vendor Subtotal w/o utilities		*$*	*3,070,000*

Notes
Total costs rounded up to two digits

Table D-2: Groundwater Corrective Measure Alternative Cost Summary Table

Ashland Greensboro Site

GCMA-1		
No Additional Action		
Task #	**Task**	**Cost**
1	None	$ -
TOTAL		**$ -**

GCMA-2		
Institutional Controls - Estimated Costs		
Task #	**Task**	**Cost**
1	IC Implementation	$ 10,000
2	Long Term IC Maintenance (30 Years)	$ 30,000
3	Propject Management (15% of Capital and Operation Costs)	$ 6,000
TOTAL		**$ 46,000**

GCMA-3		
Monitored Natural Attenuation and ICs - Estimated Costs		
Task #	**Task**	**Cost**
1	Annual Monitoring (30 Years)	$ 570,000
2	IC Implementation	$ 10,000
3	Long Term IC Maintenance (30 Years)	$ 30,000
4	Propject Management (15% of Capital and Operation Cost	$ 6,000
TOTAL		**$ 620,000**

GCMA-4		
Groundwater Recovery, Treatment, Discharge, Monitoring and ICs - Est. Costs		
Task #	**Task**	**Cost**
1	Hydraulic Evaluation and System Design	$ 20,000
2	Prepare Work Plan and Update HASP	$ 25,000
3	Permitting	$ 43,000
4	Drawings, Bid Packages, Site Walks, and Contractor Selection	$ 34,000
5	Extraction and Treatment System Construction	$ 1,030,000
6	Construction Completion Report	$ 26,000
7	Operations and Maintenance of Extraction/Treatment System	$ 2,910,000
8	Groundwater Monitoring and Reporting - Each Event	$ 646,000
9	System Repairs (Contingency Task)	$ 184,500
10	ICs Implementation and Maintenance	$ 46,000
TOTAL		**$ 5,000,000**
Contingency Costs (15% of Total)		$ 750,000
TOTAL with Contingencies		**$ 5,800,000**